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MACHINES

AND THE MEN WHO MADE THE WORLD OF INDUSTRY

GERTRUDE HARTMAN

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MACHINES
And the Men Who Made the World of Industry

By *GERTRUDE HARTMAN*

THE WORLD WE LIVE IN:
AND HOW IT CAME TO BE

THESE UNITED STATES:
AND HOW THEY CAME TO BE

MEDIEVAL DAYS AND WAYS

MACHINES:
AND THE MEN WHO MADE THE
WORLD OF INDUSTRY

MACHINES

and the men who made the world of Industry

BY GERTRUDE HARTMAN

NEW YORK THE MACMILLAN COMPANY 1947

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FOREWORD

The Magic of Machines

MACHINES have built a magic world for us. We can touch a button on a wall and instantly turn pitch-black darkness into brilliant light. We can send our thoughts over the world with the speed of lightning. We can speak to a person a thousand miles away. We can soar through the air more swiftly than the birds. These are just a few of the countless miracles of the world in which we live.

We are so used to all these things that it is hard to realize there ever was a time when they did not exist; yet until about a hundred and fifty years ago many of the things we have today were entirely unknown. There were no great machines to do work. There were no factories to make things. Most people lived on farms, where they raised almost everything they needed. Vegetables were raised in the garden. The farm animals supplied meat, and milk, and eggs. Bread was made from wheat which grew in the fields near by. Whenever anything was needed the people made it themselves. They made their own clothes, their tools and utensils. They built their own houses. They made their own butter, their soap, and their candles. What they could not grow or make they did not have.

This was the way people lived all over the world. Nowhere in the world was there a railroad, a steamboat, a telegraph, a

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telephone. Instead of riding in comfortable trains, or driving in automobiles over smooth, well-paved roads, or crossing the ocean in great steamboats as we do, our forefathers traveled on horseback, or by stagecoach, or in slow sailing vessels. There were no streetcars, no movies, no skyscrapers, no electric lights, no airplanes. In fact, most of the conveniences and comforts to which we are accustomed were not in existence. About the beginning of the eighteenth century, however, strange things began happening which put an end to the simple way in which people had lived for centuries, and brought about our complex world of today, with its busy cities and gigantic industries.

Ever since the first days of man, the natural resources and forces of the earth had surrounded the people of the world. There were streams with great power in them, the force of whose fast-flowing waters could be utilized to do man's work. Hidden away below the surface of the earth lay fabulous stores of oil, coal, iron, and other minerals useful to man. But people had not learned how to use them. Then, in the eighteenth century, the inventive genius of men found ways of making the materials and forces of nature work for them.

Thus a new age was opened up, in which people's ways of working and living were entirely changed. This time of great changes is called the Industrial Revolution.

Although the changes of the Industrial Revolution seem to have come about suddenly, nothing in the world really comes suddenly. If you investigate you will find that everything has a long story behind it, sometimes reaching back to quite early times. If you read the lives of the inventors you will find that most of them began their work where other inventors had left off. In fact, it was by utilizing the accumulated knowledge of the past that men were able to make such astonishing progress during the Industrial Revolution.

In this book we shall trace the main steps in the great transformation that has taken place in the world during the last two centuries, but when taking up the changes of that time we shall often go back and see their humble beginnings in earlier days.

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MACHINES
And the Men Who Made the World of Industry

CHAPTER I

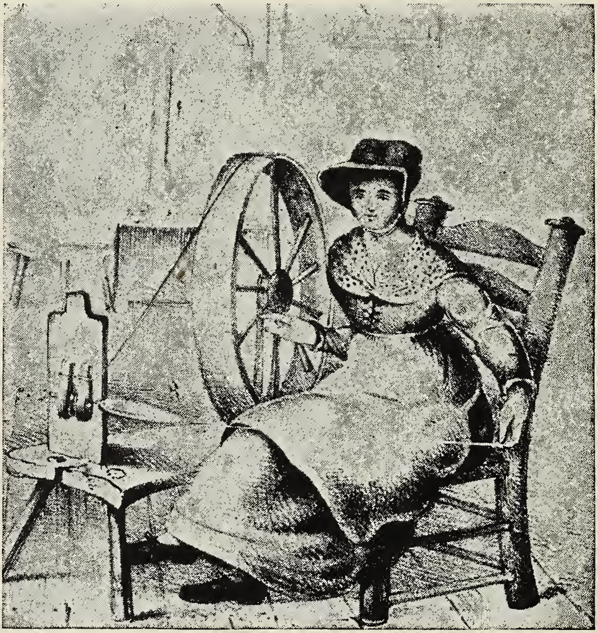
Spinning Jennies and Weaving Johnnies

THE first of the great changes which brought about the industrial world in which we are living came in England, in the spinning and weaving of cloth.

Very early in the history of the world people learned how to make cloth from wool. In the spring they sheared the sheep and brushed and combed out the tangles in the wool. Then the wool was twisted and drawn out into yarn. This process is called spinning.

The oldest method of spinning was by the distaff and spindle. The distaff was a long stick, one end of which was used to hold a supply of wool. The spinner held the other end under her left arm or stuck it into her girdle. A spindle was a slender piece of wood with a notch at one end. To the upper end of the distaff the spinner attached a loose bunch of wool, and pulling out a small piece from it, twisted it together into a thread and fastened the end of it to the notch in the spindle. With a quick, twisting motion of her hand, she set the spindle whirling and let it dangle at her side. She kept drawing out the loose wool from the distaff, and it was twisted by the whirling spindle. This process was kept up until all the wool on the distaff was spun into yarn.

The first improvement in this ancient method of spinning came with the spinning wheel, which was first used in Europe in the later Middle Ages. This was a machine in which the spindle was whirled by a wheel worked by the feet. With it one spinner could spin as much yarn as half a dozen could spin with the distaff. But even the spinning wheel was slow, for only one thread could be spun at a time.



Spinning with the spinning wheel in early days.

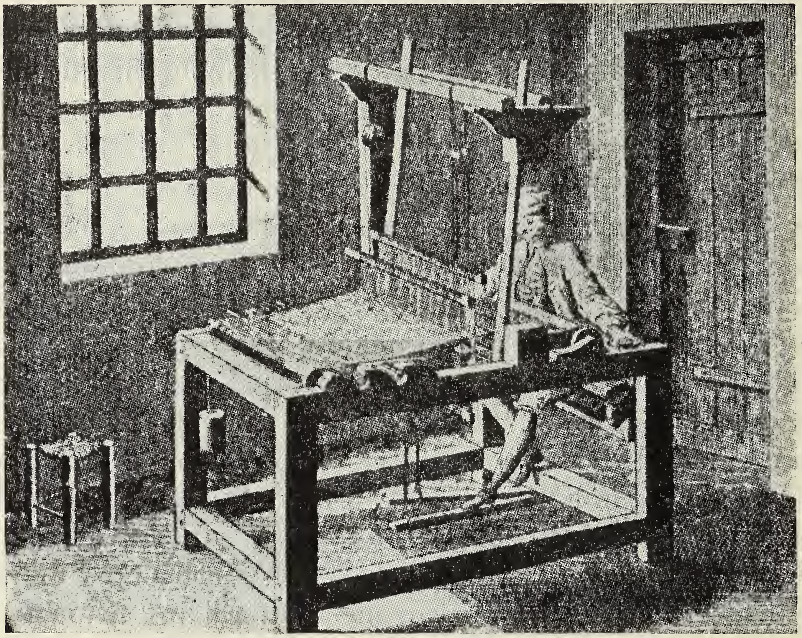
After the yarn is spun the next step in the making of cloth is weaving. All through the ages, from the very earliest times, weaving was done on a simple, upright wooden frame called a loom. On the loom were stretched tightly many threads of yarn in parallel rows running up and down. This was known as the warp. The weaver wound more yarn on a shuttle and pushed it in and out from one side of the loom to the other, under and over the threads of the warp. Forward and back, forward and back, went the shuttle, passing first over one of the up-and-down threads and under the next, interlacing the threads into cloth.

Such were the slow methods of making cloth all over the world from the dawn of civilization until about the middle of the eighteenth century. Then came several inventions which made it possible to spin and weave much more rapidly.

During the eighteenth century, England was one of the great clothmaking countries of the world. The busy hum of the spinning wheel and the clack-clack of the loom could be heard in every cottage, as whole villages busied themselves at spinning and weaving all day and far into the winter nights.

There was living in the north of England at that time a poor but ingenious weaver, named John Kay, who, in 1733, invented a simple contrivance, called the fly shuttle. This was a great timesaver for the weavers. Before this a weaver had to pass his shuttle slowly back and forth across the loom by hand. With the fly shuttle all he had to do was to pull a string with a quick jerk, and a spring sent the shuttle flying through the warp threads faster than any shuttle had been able to go before.

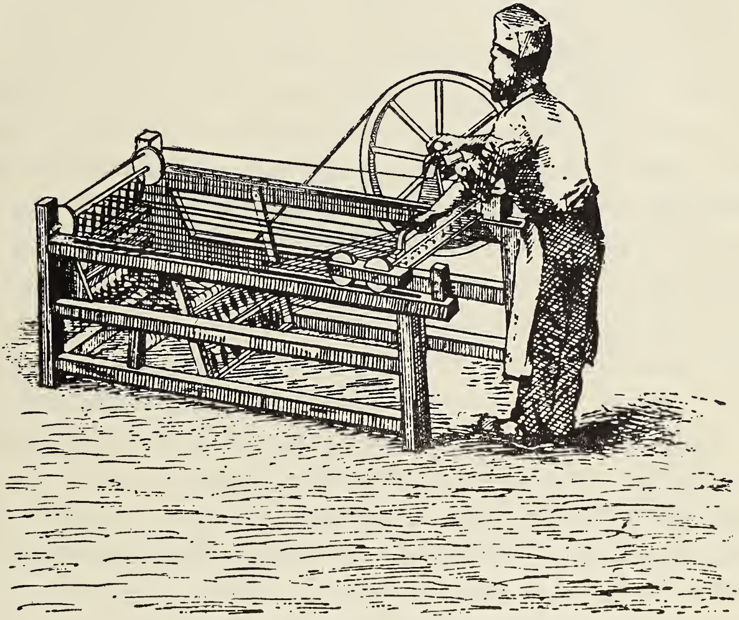
Strange to say, Kay did not benefit by his invention, for the other weavers in the neighborhood, when they heard about it, were up in arms against him. It was hard for them to make enough money to live on, and they were afraid that if everyone began using the new shuttle there would not be enough work to go around. They did not realize that the demand for cloth was far greater than the supply and that the more they could make the better off they would be. So, in great excitement, they burst into Kay's house and destroyed his flying shuttle. Poor Kay would no doubt have been killed had his friends not carried him to a place of safety hidden in a blanket. He was forced to flee for his life and died in poverty and neglect.



An old-time weaver at his loom.

Such was the sad fate that befell the first inventor who brought about an improvement in clothmaking.

In time, however, the weavers realized that the fly shuttle was a useful device, and it was widely adopted. With it they could weave much more cloth than before, and thus could earn more for their families. The only trouble was that weaving used up so much yarn that the weavers could not get enough to keep their looms busy. The spinning wheel, spinning only a thread at a time, even though it was kept turning from morn till midnight in thousands of cottages, was too slow to keep up with the weaver's shuttle. After Kay's invention the weavers were constantly complaining of the scarcity of yarn. Often a weaver had to tramp miles to collect enough yarn to begin his day's work. So people began trying to think of some quicker way of getting the spinning done.


The Hargreaves spinning jenny.

The first improvement in spinning was made in 1767, by James Hargreaves. He spent his days weaving the yarn which his wife spun for him on her spinning wheel; but as she was never able to spin enough for his needs, his loom was frequently idle for lack of yarn. He had a hard struggle to make a living. Every minute lost meant less food for his family. If only he could find some quicker way of spinning yarn! Hargreaves passed many sleepless nights thinking over his problem.

The way to spin yarn more rapidly was suggested to Hargreaves by a curious accident. One day his wife's spinning wheel was knocked over and fell with a crash to the floor. As it lay there, overturned, the spindle was in a vertical instead of a horizontal position. The wheel kept on whirling for quite a while, and as Hargreaves sat gazing at the turning wheel a wonderful idea came to him. Why not build a frame with several upright spindles side by side attached by a belt to a wheel so that when the wheel was turned all the spindles would move at once and thus spin several threads at the same time?

Very secretly Hargreaves began to work out his idea, and before long he had constructed a simple framework with eight spindles on it. He named his invention the spinning jenny, after his wife, whose name was Jenny.

After Hargreaves made his jenny, his loom was never idle for lack of yarn. To the other weavers in the neighborhood it seemed as if he spun yarn by magic. They began wondering how he could turn out so much more cloth than they could. Soon they found out the reason. The news spread rapidly that Hargreaves had a wonderful new kind of spinning machine concealed in his cottage. Then the spinners of the neighborhood rose up against the unfortunate inventor. An angry mob broke into his house, smashed his precious jenny, and drove Hargreaves from the town where he had lived all his life.

Undaunted by this hard experience, Hargreaves went to another town. There he built another machine, which he had patented, and there fortune was more favorable to him, so that he was able to live and work for the rest of his life in peace.

Two years after the invention of the spinning jenny, another spinning machine was invented by Richard Arkwright. Arkwright's life, like that of so many other inventors, was one of poverty, misfortune, and endless discouragement. But because of his perseverance, success came to him in the end.

Arkwright's parents were very poor, and when he was a small boy he was apprenticed to a barber. Later he took up the business himself in a little underground cellar. He soon showed that he was a good businessman. When other barbers were charging two pence for a shave, Arkwright hung out a sign bearing these words, "Come to the underground barber. He shaves for a penny."

Arkwright became a first-rate barber, but he was restless and ambitious. All the time he was shaving his customers or cutting their hair, he was wishing he might do something more profitable. When he was thirty years old he decided to give up being a barber and become a dealer in hair.

At that time it was the fashion for the upper classes of society to wear enormous wigs and there was a great demand for hair. Much of it was obtained from poor women and girls with beautiful hair who were willing to sell it. Arkwright traveled about the country buying hair from poor people which he made into wigs. As he went about from cottage to cottage he met many spinners and weavers and talked to them about their work. Thus he picked up much valuable information about the new machines—how they were made, and how they worked.

Arkwright became interested in the idea of making a spinning machine himself. The yarn made by the spinning jenny was not of very good quality. Arkwright thought he could make a different kind of machine that would produce better yarn. His idea was that the wool could be spun by being passed through two rollers, turning like those of a clothes wringer. With the help of a good mechanic he set to work to make such a machine. He became so absorbed that he neglected his business and spent all his savings until his family were in want.

By the year 1769 Arkwright had succeeded in building a machine run by water power, which was, for that reason, called a water frame.

Poor and friendless, Arkwright found it difficult to get anyone to help him financially with his invention. But at last he succeeded in convincing Jedediah Strutt, a man of wealth, of its value, and induced him to become his partner. In 1778 a mill was erected for spinning by the new process.

The workers rose up against Arkwright just as they had risen against the other inventors. Once his mill was burned down by a mob of spinners. But in spite of everything, Arkwright succeeded, and wealth soon began to flow his way. He finally became one of the most important mill owners in England.

Great as were the improvements made in spinning by the jenny and the water frame, the yarn spun by both of these machines was coarse and full of knots. In 1779 came another spinning invention by Samuel Crompton, which made possible the spinning of fine yarn.

Samuel's father was a poor farmer. He died when Samuel was quite a little boy, and after his death young Crompton became the main support of the family. He spent most of his time weaving. He found his work very hard because his yarn was continually breaking and he wasted much time mending it. "I was plagued to death," he said, "with mendin' the ever-breaking ends of my miserable yarn." While he was doing this, he could not help wondering whether a machine could not be made that would spin stronger and finer yarn than either the spinning jenny or water frame could make.

When he was twenty-one years old Crompton began trying to invent such a machine. His task was no easy one. He had only a few tools to work with and the only time he could give to his invention was at night after his day's work was over. Often dawn found him still at work.

While Crompton was working on his invention, late at night, his neighbors heard strange sounds coming at most untimely hours from a large upper room in his house, and lights were seen glimmering through the casement windows. Two old ladies who lived close by declared that they heard noises of a humming nature as if the devil were tuning up his bagpipe and his assistant were dancing a reel. So the rumor spread through the neighborhood that the old, rambling house was haunted.

For several years Crompton worked on his invention. "Though often baffled," he tells us, "I as often renewed the attempt, and at length succeeded to my utmost desire, but at the expense of every shilling I had in the world." He called his machine the spinning mule. With it he could spin yarn of the finest quality.

Just as Crompton finished his machine, riots broke out among the workers in the neighborhood. "The machines," they said, "are eating our bread." Mobs went about shouting, "Down with the machines and down with the traitors who invented them!" and they hacked to pieces all the spinning jennies and water frames they could lay their hands on.

Knowing that his invention would arouse the wrath of the rioters and fearing that they would destroy it, too, Crompton cut a hole in the wall of the room where he worked, and whenever there was trouble in the neighborhood, took his precious machine to pieces and hid it in this secret place. There it sometimes stayed unused for weeks.

Crompton's only idea in inventing the mule was to make a machine that would help him in his work. But his invention could not be concealed long, for the yarn it spun was much better than any that could be produced on other machines. When the other spinners of the neighborhood heard about Crompton's fine yarn they wanted to know how it was made. It was soon whispered about that he had invented a machine which he had hidden in his house, and his neighbors determined to find out whether this was so.

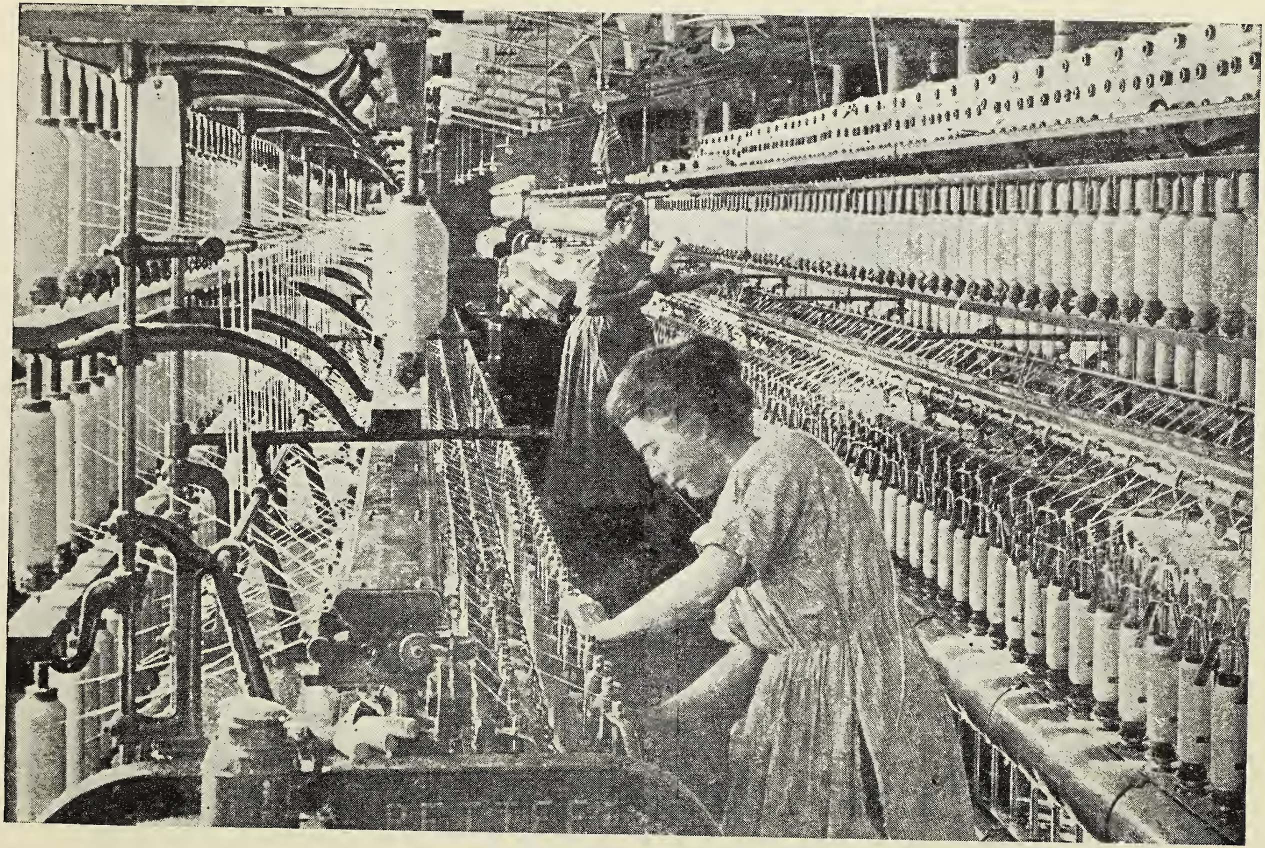
Crompton tried in every way to keep his neighbors from learning about his invention, but it was impossible. When he refused to let them in his house, they brought ladders and climbed up to the windows to try to see his machine. The continual spying made Crompton very unhappy. "A few months reduced me," he afterward wrote, "to the necessity either of destroying my machine altogether or of giving it to the public. It was not in my power to keep it and work it. To destroy it, I could not think of; to give up that for which I had labored so long was cruel. In preference to destroying it, I gave it to the public."

Crompton had no money to patent his invention and never received from it the reward he deserved. In his old age, however, the government gave him a pension in recognition of the great benefit his machine had brought to England.

The spinning machines increased the supply of yarn enormously. After they came into widespread use, spinners could spin so much yarn that the weavers had far more than they were able to weave on their old hand looms, even with Kay's fly shuttle. For nearly fifty years after Kay's invention no important improvement had been made on the loom. The time was ripe for a weaving machine. In 1787 came the invention of a new kind of loom by Edmund Cartwright, which greatly speeded up the work of the weavers.

Edmund Cartwright was a quiet country parson, who had had no experience in weaving and had never seen a loom in operation. Often he heard the people of his parish talking about the hard lot of the poor weavers. This led him to take an interest in the new machines.

One day Cartwright was at dinner with a party of gentlemen. They were talking about the new spinning machines. "Before long we shall have weaving Johnnies as well as spinning Jennies," remarked Cartwright. His companions laughed at the idea, declaring that weaving was too compli-



Courtesy Keystone View Company

In a modern spinning mill one worker tends many spindles.

cated a process to be done by a machine. Nevertheless Cartwright thought that a machine might be devised, and he decided to try to invent one.

As Cartwright knew nothing about weaving he immediately set to work to study looms carefully. He visited a neighboring mill many times. Often he would take long walks in the country, making strange gestures with his arms, imitating the motion of the new loom which was beginning to take shape in his mind. Soon he became the laughingstock of the neighborhood.

At length, with the help of a mechanic and after long, patient labor, the inventor succeeded in making a strange-looking weaving machine run by water power. It was so heavy and so hard to handle that it took two strong men to work it, but later on it was greatly improved. It was found that one weaver could tend more than one loom, so one person could accomplish as much as several had been able to do before.

With the invention of these simple machines for spinning and weaving in the eighteenth century, England took the first steps in the Industrial Revolution, which was to transform the world. Little did the spinners and weavers of that day dream what vast changes their inventions were to make in the world's history. All they were thinking of was finding ways to make their work easier and earning more money to provide for their families. But their inventions were followed by a series of other changes, which, in the course of the next two centuries, brought about a civilization entirely different from any that had existed in the world before.

CHAPTER II

Eli Whitney Invents the Cotton Gin

Most of the cloth made by the early machines was woven from wool, or from a combination of wool and flax. Very little cotton cloth was used, as cotton was very expensive. The reason for this was that cotton is full of seeds, which cling tightly to the fiber. These seeds have to be taken out before the cotton can be spun. The only way of doing this known before 1793 was to pull them out by hand. This was a slow, tedious task, and even the most skillful workers could separate only a pound or two of cotton from its seeds in a day.

Some cotton was raised on the plantations in the southern part of the United States, where negro slaves worked in the fields under the watchful eyes of white overseers. Early in the spring the negroes began plowing long, deep furrows in the mellow soil; and then came the planting. In June beautiful flowers appeared in the glossy dark-green foliage, and the wide-stretching fields were transformed into vast flower gardens of variegated beauty. In October the cotton pods, which had grown to the size of a filbert, brown and hardened like a nut, burst open, and the snowy fleece within spread out in a fluffy ball.

When the cotton fields were white, the slaves, old and young, were set to the task of picking. Up and down the rows of cotton plants they went, picking off the bolls and pil-

Picking cotton in the South.

ing up the white fluffy cotton in huge baskets. At sunset men, women, and children trooped home with the overflowing baskets poised on their heads. In the evening the negroes sat in front of their cabins, picking the seeds from the cotton, perhaps by the light of flaming pine torches.

Before the day of the cotton gin, slaves picked the seeds out of the cotton by hand. It was slow, tedious work.

It is easy to see that very little cotton could be made useful in this way. With the new machines for spinning and weaving, quantities of cotton could be used and large crops could easily be raised in America in the warm, sunny South, if only some machine could be made which would separate the seeds quickly from the cotton. Just at this time there was growing up, on a New England farm, a boy who was later to give the South such a machine. His name was Eli Whitney.

As a small boy Eli had a great fondness for pulling things to pieces to see how they were made and how they worked. His father's big silver watch particularly interested him. He wondered what made it tick and what made the hands move. He decided to find out the first time he had a chance.

Eli's opportunity came one Sunday morning when his father went to church and happened to leave his watch at home. Eli flew to the room where the watch hung and, taking it down, pried open the back. Fascinated, he watched all the little wheels going around and around inside the watch. The curious boy was not long in finding the tiny screws that held them in place. He was so deeply interested that before long he had taken the whole works to pieces, bit by bit. When he realized what he had done he was terrified, for his father was very strict and would be sure to punish him. Could he ever put the watch together again?

Feverishly Eli set to work and succeeded in putting the works together just as they had been before. It was not until years later that he dared to tell his father of his Sunday-morning experiment.

When he was quite young Eli's natural gift for making things began to show itself. Once his father was away from home for several days and, on his return, asked the housekeeper how each of his boys had spent his time during his absence. He learned that one had weeded the onions, and another had mended the stone wall between the fields.

"But what about Eli? What has he been doing?"

"Oh, he has been making a fiddle," the housekeeper answered.

"I'm afraid that boy will fiddle away his whole life," said his father. "I should like to see him do something useful."

The fiddle proved to be a very fine piece of work and made good music. After that all the musicians in the neighborhood brought Eli their violins to mend when they were out of order.

One day Eli's mother showed him a set of dinner knives that had been given her for a present. She was very proud of them.

"These are very fine knives," she said. "They were made in England. Nothing like them could be made in this country."

Eli examined them closely. In a few moments he said, "I could make them myself if I had the tools."

Soon afterward Eli had an opportunity to prove the truth of what he had said. One of the valued knives was broken by accident. Eli took it to the shop, and with his clumsy tools made a knife so like the broken one that the only way Mrs. Whitney could tell it from the others was because the stamp of the manufacturer was not on the blade.

Later Eli began to use his skill to make money for his father. This was the time of the Revolutionary War, and all trade between England and America had stopped. There were few manufactures of any kind on this side of the Atlantic. The people depended upon England for even such little things as nails.

Nails were made by hand and were much more expensive than they are now. Eli had often made small quantities of nails for the family. Now that they were so scarce it seemed to him that there would be profit in making them to sell. He talked with his father, saying he felt sure he could make the undertaking pay if he had certain tools. The idea pleased his father and he bought the necessary tools. So Eli went to work. From that time till the close of the war the young mechanic spent all his spare time making nails.

When Eli grew up he wanted to go to college; so he entered Yale University. After graduating, he decided to teach, and accepted a position in Savannah, Georgia. When he arrived there, he discovered that the position was not what he had expected, and he found himself in a strange place, with no job and no money.

On his trip to the South by boat Whitney had made the acquaintance of a Mrs. Nathanael Greene, who was on her way to her beautiful Southern home, Mulberry Grove, not far from Savannah. When Mrs. Greene heard of the young man's sad plight she sent for him and said, "My young friend, make my house your home."

Whitney was very grateful to Mrs. Greene for her generosity, and tried in every way to show his appreciation. If anything was out of order in the house he seemed to know exactly what was needed to make it right. He made wonderful toys for the children and repaired others that were broken.

One evening, when Mrs. Greene was making some embroidery on a frame, she complained that the frame tore the delicate threads of her work. An evening or two later Whitney presented her with a new frame made in a different way. It was so much better than the old one that Mrs. Greene was delighted and wanted to know where he got the idea.

"Oh, I just got it out of my head," said Whitney.

Mrs. Greene began to look upon Whitney as a mechanical genius.

One day a number of plantation owners were gathered at Mrs. Greene's house. They were discussing the growing of cotton and all agreed that they could raise great quantities of good cotton but that there was no profit in doing so because it cost so much to take out the seeds. Mrs. Greene, recalling how many things Whitney had made and mended, said, "Why don't you apply to my young friend, Mr. Whitney? I really believe that he can make anything." And she took them into a near-by room and showed them many of the things Whitney had made.

Whitney was called in, and the planters asked him whether he thought he could contrive a machine that would separate the seeds from the cotton. He was much interested in the idea and said he thought that he might be able to make a machine that would do the work.

Whitney had no money to spend in making the experiment. Mr. Miller, who had charge of Mrs. Greene's estate, offered to become his partner, and furnish the necessary money, and Whitney gladly accepted this offer. Mrs. Greene had a shop fitted up in the basement, where Whitney was soon at work.

Toward the end of the winter of 1793 the clever young inventor had completed a simple machine, which was called a gin (short for engine). It consisted of a box, or hopper, across one side of which was an iron grating with narrow slits in it. In the hopper was a cylinder armed with rows of wire teeth. The cotton was put into the box, the cylinder was turned, and the sharp wire teeth seized the loose cotton, forcing it through the slits and dropping it on the outside in soft, fluffy masses. The seeds, which were too large to go through the grating, were left behind in the hopper.

What an exciting moment it was when Whitney put cotton into the hopper, turned the crank, and watched the snowy cotton falling outside the hopper free from seeds! But a difficulty soon appeared. The teeth of the revolving cylinder very quickly became clogged with cotton fiber, and the gin had to be stopped to remove it.

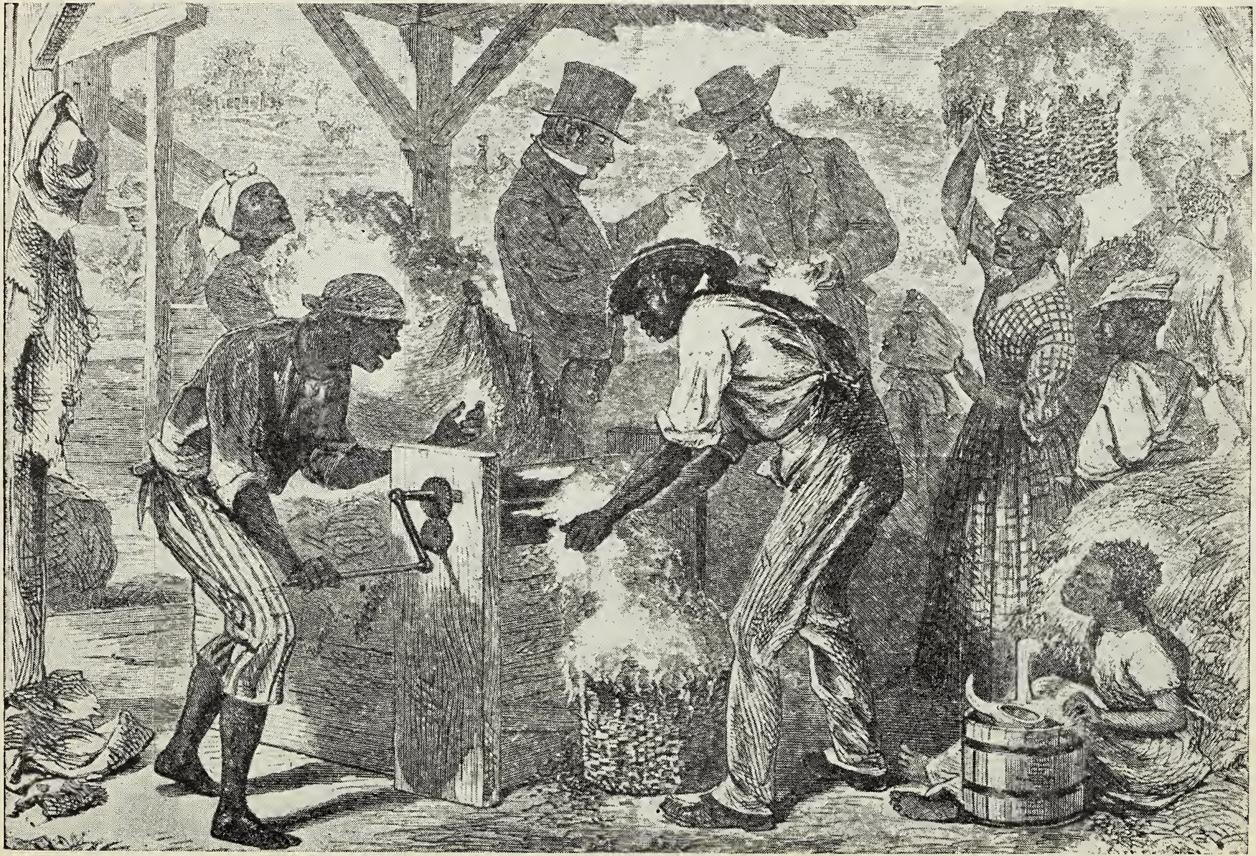
Whitney was wondering how to solve this problem when Mrs. Greene, picking up a brush from the hearth, said, "Why don't you use something like this?"

"Just the thing!" exclaimed Whitney.

In the machine he placed another cylinder carrying stiff wire brushes. He made it turn toward the toothed cylinder and move four times as fast. As the two cylinders revolved, the brushes on one cylinder swept the cotton off the wire teeth of the other.

As soon as the gin was finished, Mrs. Greene asked her planter friends to come to see the marvelous labor-saving machine that Whitney had made. The planters looked on in amazement and realized with delight that with this little machine more cotton could be separated from the seeds in one day than could be done in a month in the old way. By using it, they could raise cotton at a good profit. So enthusiastic were they that they talked about the new invention everywhere; and as the news spread, crowds of curious people came from near and far to see the wonderful machine.

Whitney did not want people to see his invention until he had secured a patent. The government issues patent rights to an inventor who applies for them. Then the invention is his property and anyone who makes a machine without having received from him permission to do so is liable to be fined or



Cleaning cotton with one of the early gins. (*Harper's Weekly*, December 18, 1869) otherwise punished. One night, however, the shed in which the precious gin was kept was broken open and the machine was stolen.

There were troublous times ahead for the young inventor. Many planters had planted cotton expecting to take out the seeds with Whitney's gin, and Whitney could not make gins fast enough to supply them. What were the planters to do? If they did not get the gins thousands of dollars' worth of cotton would be lost.

The gin was so simple in construction that any good carpenter could make one; so many of the planters had neighboring carpenters and blacksmiths make gins for them. There were long trials in court, in which Whitney tried to protect his invention. At last, after more than sixty trials, which cost Whitney almost as much as he made out of the cotton gin, he came out victorious.

The inventor spent thirteen of the best years of his life on the cotton gin; in return he received from it little more than enough to pay his debts. But if the cotton gin failed to bring wealth to Whitney, it brought a great tide of prosperity to the South. The new spinning and weaving machines created a demand for all the cotton the South could produce. It was not long before cotton gins, run by steam, were able to clean a thousand pounds of cotton in a day. Some of this was shipped to England and some was sent to mills in New England, where the white snow of the cotton fields was converted into cloth.

After the invention of the cotton gin, clothing made of cotton became so cheap that it could be bought by even the poorest people. Thus a great contribution was made to the work of clothing the people of the world.

CHAPTER III

Buried Treasures

THE use of machines created a great demand for iron and coal. In the early geologic ages of the earth, long before there were any people in the world, nature had buried vast deposits of these two industrial treasures in many places beneath the surface of the earth. But it was not until the eighteenth century that they were brought forth to any extent.

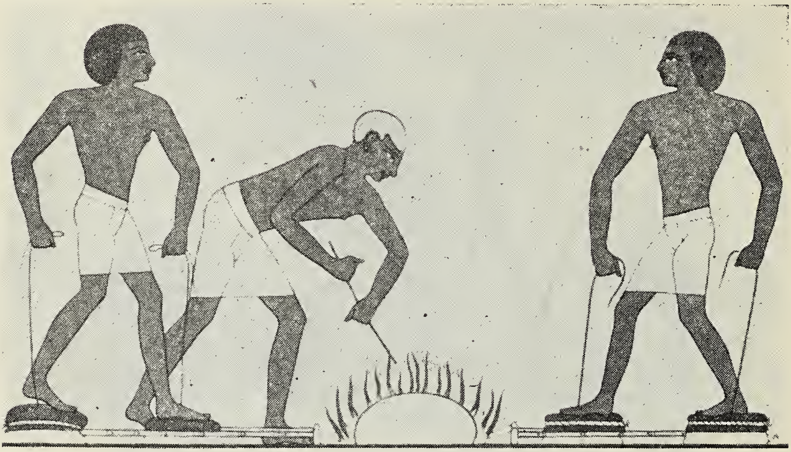
Iron, as it occurs in nature, is almost always mixed with clay, rock, and other substances. We call this combination iron ore. It requires great heat to get the metal out of the ore. We do not know when man first began to use iron. It was sometime in the early ages of the world. The first ironworkers heated the ore until the iron was melted out. This process is called smelting.

On some high place, like a hill, where there was plenty of wind to make the fire burn well, the ironworkers heaped up a big pile of wood. They broke up rocks containing iron into small pieces and piled them on top of the wood. They covered this with stones and dirt to keep in the heat, made a hole in the top to let out the smoke, and several holes in the bottom to let in air to make the fire burn better. In time the iron melted out of the ore and trickled down to the bottom of the pile; here it was allowed to cool, forming a lump of metal.

These hillside furnaces worked well enough when there was a good wind. But the wind could not always be depended upon to keep the fires of the ironworkers hot. Sometimes it blew strongly enough to make a good draft, and sometimes it did not. After a while the early metalworkers learned a more dependable way of getting a blast of air to smelt their iron. By blowing into the fire through long tubes, they fanned the flames into a hotter fire. On the walls of Egyptian temples are pictures showing boys squatting around a fire, each with a long pipe through which he is blowing on the fire to smelt ore.

Men smelting iron in the early days of the world.

That method of making a good flame was very hard work. In time the Egyptians discovered a better way of forcing air into the fire by means of bellows of various kinds. One kind of bellows was made of two goatskins connected with a pipe which carried the air into the fire. The operator stood with one of the goatskins under each foot. In each hand he held a cord. When he pulled a cord it lifted the upper part of the goatskin to which it was attached and let the air in through a hole in the top. As he pulled up one cord to let air into one goatskin he pressed the other goatskin down with the opposite foot, sending a current of air through the pipe into the fire. Thus he worked all day long, filling the bellows with air by pulling the cords with his hands, and forcing the air into the fire with his feet.



Early Egyptians using bellows worked by the hands and feet to smelt iron.

In the course of time, furnaces were built to hold the ore; charcoal, or charred wood, which makes a hotter fire, was used instead of wood; and more powerful bellows, worked by horse power or water power, came into use. With a more powerful blast of air the ironworkers could build their furnaces higher and still force the air through. Thus came into existence during the Middle Ages the blast furnace, which was like a short, fat chimney. The white-hot liquid trickled down to the bottom of the furnace and collected in a broad trench made for it on the hearth. Opening off this were smaller trenches. It is said that because these trenches seemed to resemble a mother pig with her family of little pigs, the product

Medieval ironworkers.

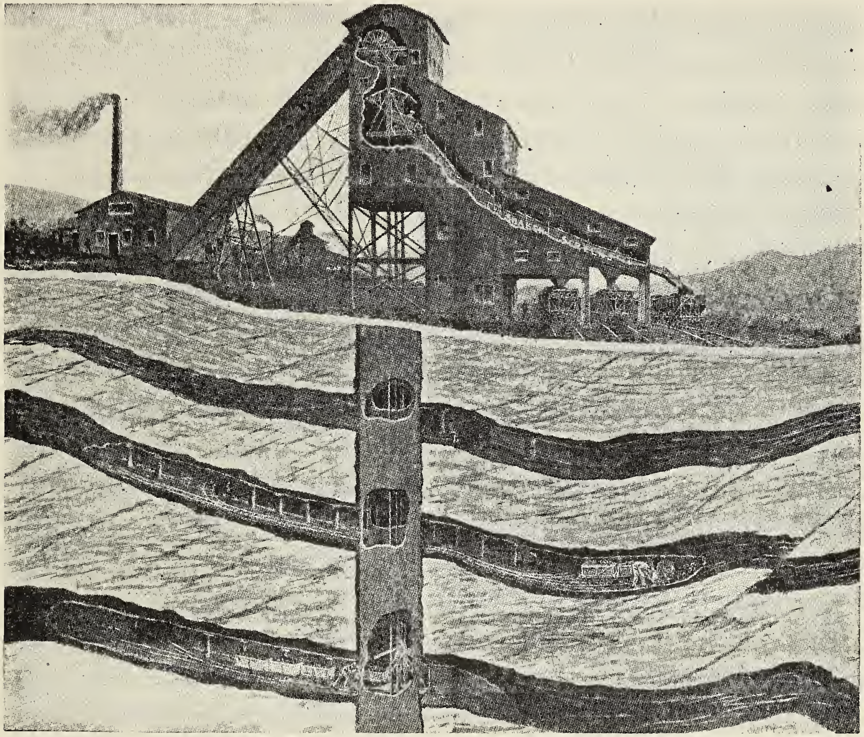
of the blast furnace came to be called pig iron; and so it is called today.

By such slow methods as these, men in early ages succeeded in getting small quantities of iron. This was used only for small things made by hand. For centuries no better way was known and throughout ancient and medieval times iron was scarce and expensive because of the difficulty of producing a fire hot enough to smelt any quantity of iron out of the ore.

In an effort to supply the steadily growing demand for iron in England in the eighteenth century, ironworkers built their furnaces higher and higher. These larger furnaces took tremendous amounts of charcoal to keep the fires burning. So many trees were being cut down to make charcoal that the forests all over the country were fast disappearing. Shipbuilders began to fear that soon there would be no more trees left with which to build ships. That would be a terrible calamity for England, which had been busy for centuries building up a great trade with the rest of the world. What would the little island country do without ships? Her whole prosperity depended upon them. The English Parliament acted swiftly to save the forests for the shipbuilders, by passing a law forbidding trees to be cut down for making charcoal.

What were the ironworkers to do? Fuel for their furnaces they must have. If they could no longer use wood they must find something else for fuel. Fortunately, under the soil of England were vast quantities of coal, which was a far better fuel than wood.

Let us see how coal came in England and in other places under the earth's surface. Millions and millions of years ago, long ages before man came upon the earth, beautiful trees and luxuriant plants grew in many places. During those ages the climate of the earth was very warm. From time to time the folding of the earth's crust made deep hollows in the earth's surface and water filled these hollow places, making a kind of swampland. In these warm, steaming marshes grew tall trees and gigantic ferns—some of them as high as trees—and a thick



Courtesy Scientific American

A cross section of a modern coal mine showing how it would look if you could see into it. You can see the miners at work in the coal veins, and the coal dumped from the breaker into the coal cars.

undergrowth of strange-looking plants, unlike any we have today.

As the land sank lower and lower, more water settled in the swamps of the early world. Sometimes terrible hurricanes swept through the forests. The giant trees swayed back and forth and frequently, torn up by the roots, went crashing down to the ground. There they lay, their great masses of tangled roots and branches decaying in the warm moisture, gradually becoming thick beds of matted vegetable matter.

These beds of decaying vegetable matter sank farther and farther down in the soft, swampy earth until they were entirely covered with water. The water kept depositing sand and mud upon them, burying them deeper and deeper and crushing them together into a more and more solid mass, until in the course of time they were hardened into a black, rocklike substance.

After a time the land rose once more and other forests grew up. Again the great trees and ferns fell into the swamps and were buried under thick layers of silt. This rising and falling of the land continued for thousands and thousands of years. Each time the land rose, new forests grew up; every time the land sank, the trees and plants fell and were buried. It was in this way that the ancient forests were changed to seams of coal under the earth, separated by layers of rock. Coal is, therefore, really wood, buried through the movements of the earth's surface and changed by heat and pressure.

For millions and millions of years after coal was formed it lay buried under the surface of the earth, and for thousands of years men lived upon the earth before they discovered that coal was good for fuel. The forests supplied plenty of wood, and wood was used for fuel during these thousands of years. In some places, however, where coal was found near the surface, people had learned to use it.

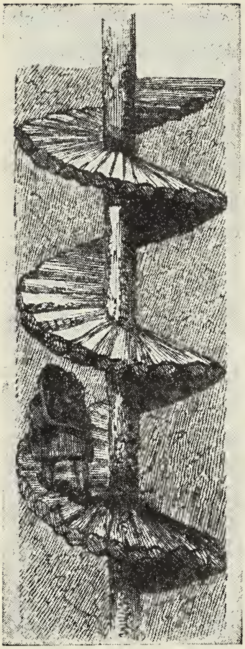
In England, as far back as 1619, a young man named Dud Dudley, the son of Lord Dudley, had used coal to get iron from the ore. His home, Dudley Castle, was in an ironmaking center. The iron was smelted with wood. There was plenty of coal in the region but it never occurred to anyone to use it for smelting. The wood in the neighborhood was almost exhausted and Dud Dudley decided to use coal. First he had to turn it into coke, which he did by a process he had invented. Presently he was making three tons of iron a week.

Soon the other ironmakers of the region were amazed to find Dudley turning out good iron at a price lower than that which they could produce by using charcoal. They banded against him and forced him to give up his works.

Dudley moved to another place, built a larger furnace, and opened up new coalpits. Soon he was turning out seven tons of iron a week. The charcoalmakers saw that if coal came into general use they could no longer sell their charcoal to the ironmakers, so a mob of charcoal men broke into Dudley's works, destroyed everything they could lay their hands on, and left the place in ruins. Poor Dud Dudley was thrown into prison for debt. People tried to get him to tell them about his process of making iron, but he refused and his secret died with him.

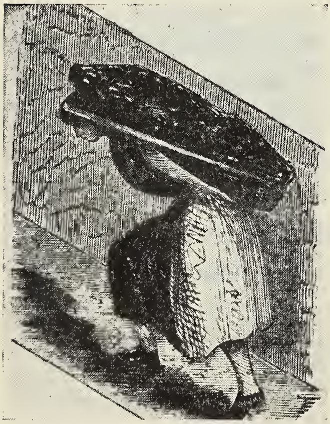
Such were the troubles of the first man in England who tried to use coal to smelt iron.

It is not until nearly a century later that we hear of further attempts to smelt iron with coal. Then another ironmaker,



Abraham Darby, finding the wood in his neighborhood scarce, tried using coke made from coal in his furnace and was very successful. He was followed by his son, and by 1747 the Darby Works at Colebrookdale were celebrated for making the best iron in England.

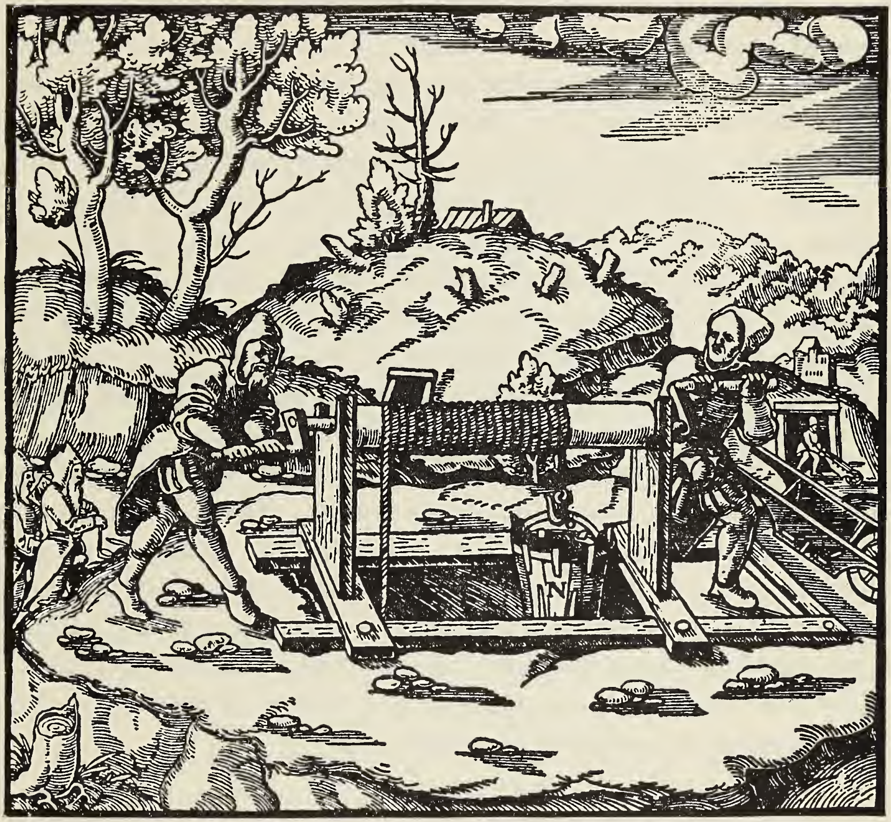
As the demand for iron increased, more and more ironmakers began smelting the new way, using coke made from coal for fuel instead of wood. Then more coal than had ever been used in the world's history was needed. At first, shallow pits of coal were dug out; but as the demand steadily increased, men had to burrow deeper and deeper into the earth for it.



Women carried the baskets of coal up steep stairways.

Getting the coal out of deep mines was a backbreaking task. Men and women toiled long hours far down under the ground and carried the coal up to the surface in baskets on their backs. In some mines the passageways were so small that grown people could not get in; so children were employed. They were harnessed to little cars which were fastened by chains around their waists, and they had to crawl on their hands and knees through the narrow, dark, underground passageways, push-ing and pulling the cars to the main shaft of the mine.

As mines grew deeper, a better way of raising the coal was needed and various kinds of hoisting machines were used. One of these was the windlass. Near the entrance of a mine a wooden roller was installed, turned by handles. A rope with a bucket fastened to the end was attached to the roller and let down into the mine, where it was filled with coal. Then the



Miners raising coal and water from a mine by means of a windlass.

men above turned the roller in the other direction, winding the rope around it, and thus pulled up the buckets of coal.

Soon another and even greater difficulty arose. When mines were dug deep into the earth, water from the springs in the ground near by drained into them. This made it dangerous, and often impossible, to continue mining. In some mines the water was bailed out by a chain of buckets. When the buckets reached the top they tipped over, emptying out the water into a trough. Then the empty buckets went down into the mine again. Sometimes this chain was turned by a man down in the mine, treading inside a big wheel to keep the chain moving. In some mines horses were used to drive the treadmills. Around and around the opening of the mine they walked, turning a coil of rope over pulleys to which buckets were attached and lowered and raised from the mine.

Thus the miners of England struggled in every way they could think of to free mines from water. But still the water got ahead of them. The greatest need of the time was a machine to pump water out of the deep mines and raise the coal, and do this quickly and cheaply. Unless something of the kind could be invented many mines would have to be closed. How the need for such a pump led to the invention of the steam engine we shall tell in a later chapter.

CHAPTER IV

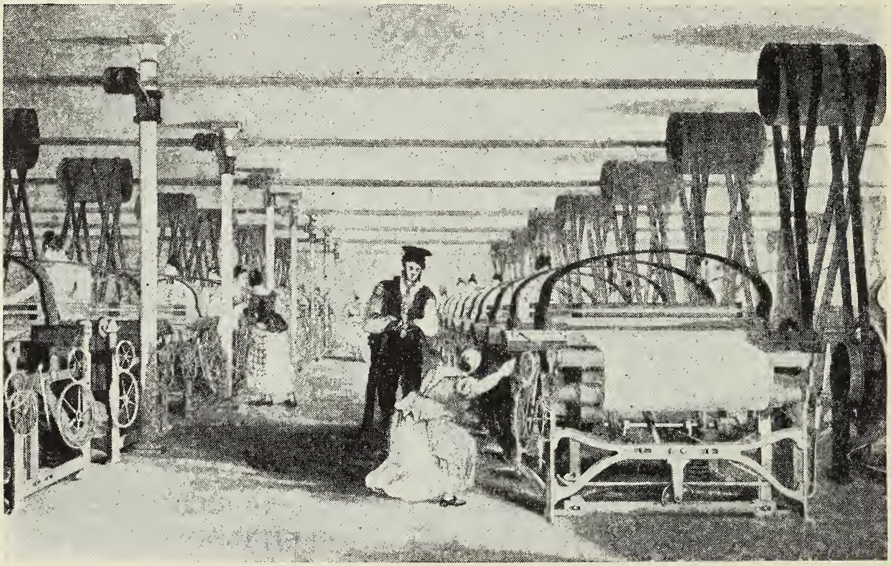
The Old Order Changeth

ALL the new spinning and weaving inventions aroused the opposition of the workers, as we have seen. But the handworkers could not compete with the machines. The tireless machines could produce goods much more quickly and thus lower the price for which they could be sold. So people stopped buying the handmade goods and, instead, bought the cheaper machine-made goods. Soon the handworkers' trade was gone. The age of the machine had come.

Most spinners and weavers were too poor to buy the new machines. Any man who wished to make a business of spinning and weaving, and who could get enough money, bought a number of machines and put up a large building, called a mill or factory. Then he bought a quantity of materials, and hired people to work for him. Before long most manufacturing in England was being done in factories.

In America, as in every other country except England, yarn was still being spun by the spinning wheel, and cloth was still woven on the old hand looms. When news of the wonderful new machines in use in England reached the United States, businessmen wanted to introduce machines into this country. They tried to invent similar machines, but without success. Then they tried to import machines from England, but this was very difficult.

England, because of her spinning and weaving inventions, had become the leading manufacturing country in the world. Her machine-made goods sold everywhere because they were cheaper than the handmade goods of other countries. Without machinery no other country could compete with her. So Parliament passed laws forbidding any machines, or models, or plans, or even descriptions of machines to be taken out of England; and strict watch was kept to prevent any from being taken out of the country.



An early factory in England with power looms.

At that time there was living in England a young man by the name of Samuel Slater. From the time he was fourteen years old he had worked as an apprentice in the mill of Jedediah Strutt, the partner of Richard Arkwright. He had therefore had an excellent opportunity to learn all parts of the business.

One day he happened to read in a newspaper of the rewards that were being offered in the United States to anyone who could construct machines like those in England, and he decided to go to America. Slater kept his plans secret. He knew that he would not be allowed to take any machines, or models, or plans of machines with him. But he had a good memory, and there was nothing to prevent him from carrying the plans of the machines in his head! So he remained in England until he knew every part of the new machines so thoroughly that he could construct them from memory.

Slater landed in New York in November, 1789. There he learned that Moses Brown, who had a hand-loom mill in Pawtucket, Rhode Island, had been trying to get machines like those in England. Slater wrote to Moses Brown, telling him that he could construct machines and offering his services.

"I flatter myself," he said, "that I can give the greatest satisfaction in making machinery."

The old Quaker replied to the unknown English lad, "If thou canst do what thou sayest, I invite thee to come to Rhode Island and have the credit of introducing cotton manufactures into America."

Slater wrote back, "Under my proposal if I do not make as good yarn as they do in England, I will have nothing for my services, but will throw the whole of what I have attempted over the bridge."

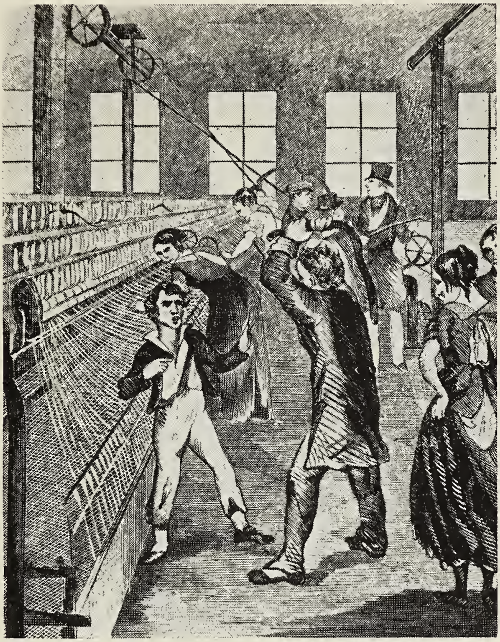
Arriving in Pawtucket, Slater began building, from memory, machinery like the English machines. He had to make almost all the machines himself, by hand. On December 2, 1790, they were ready to be set going with water power. They were found to work successfully, and the firm of Almy, Brown, and Slater was formed for making yarn by machinery. In this way the factory system was introduced into this country.

Within a short time men who had learned the business from Slater built their own mills in other places. Soon the making of cloth became one of the leading industries of New England. The falls in the rivers of this region were utilized to furnish power for the machinery. The swift-flowing waters of the streams turned water wheels, to which were attached the looms and spindles in the mills.

The new methods of manufacture by machines, applied at first to the making of cloth, gradually spread to all sorts of industries. Thus the factory system developed in the United States as well as in England.

With the coming of the factory the whole life of working people was changed. Instead of working for themselves in their homes, as they had done before, they had to go out to work for someone else. In their homes they had been free to begin work when they wished and remain at it as long as they liked. They were more or less their own masters. But in the factory the hours and the conditions under which they worked were no longer of their own choosing. The employers decided how long their employees should work and how much money they should receive. No longer were the workers their own masters; they had lost their independence and were dependent for their livelihood on the factory owners.

The machine brought with it another change in the way people worked. Before machines were invented each man made an entire article. With the factory there came a much quicker way of working. It was Eli Whitney, the inventor of the cotton gin, who first thought of this new way. When Whitney realized that there was no hope of his profiting by his invention, he built a factory in Connecticut and began making muskets. There he worked out another idea as important to industry as the cotton gin.



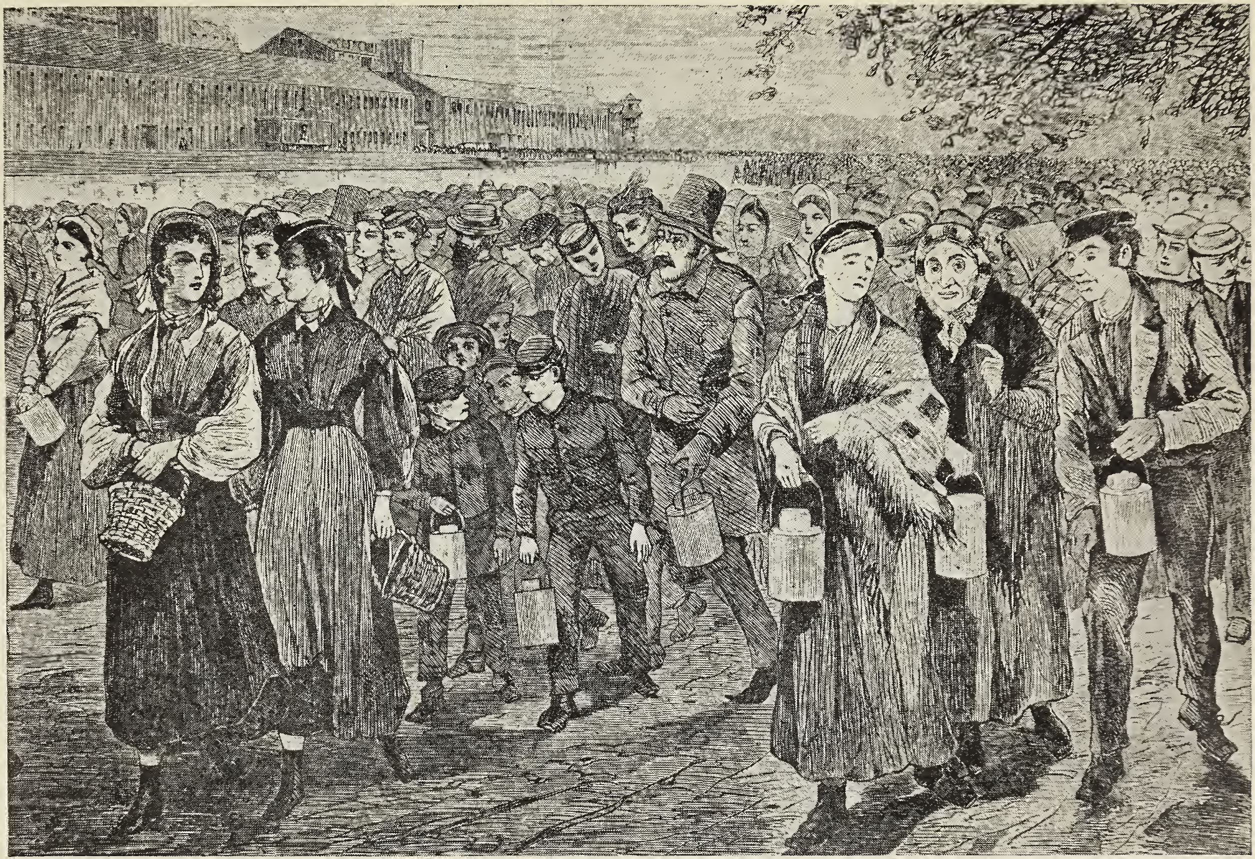
Boys and girls had to work long hours in the mills.

At that time guns were made entirely by hand. Because of this no two parts were exactly alike and when the lock of a musket, or some other part, was broken, a person had to buy a new gun. Whitney invented machines to make every part of a gun. As these parts were machine-made they were all exactly alike. When muskets were made by this method, if a man broke the lock of his gun, or some other part, it could be replaced at a slight cost by a new piece which was sure to fit. Whitney also changed the way men worked. In his factory each workman, instead of making a whole gun, had one machine to tend which made a special part of a gun. This new way proved so successful that other manufacturers soon applied it in their business.

Thus, with the coming of the factory, what had formerly been one person's work was divided up into many parts. This is called division of labor. By this method workmen did the same kind of work over and over. A machine made each part of an article and the workman became merely a tender of the machine.

This monotonous work was a great contrast to the varied tasks of earlier times. Although, before the days of machines, hours of work were long, people could change from one job to another. In their homes there were cooking and housework to be done, the milking of cows, the making of butter, plowing and planting, the shearing of sheep, and so on. But with the coming of machines the worker was required to stand at his machine all day long, doing the same kind of work over and over, day after day, year in and year out.

In most factories the hours were cruelly long. They opened at sunrise and did not close until late at night, especially in the summertime. Wages were very low. As a father could not earn enough to keep his family, the whole family had to work. The children worked as long hours as their parents did. From the time they were four or five years old they worked



Early mill hands on their way to work. (*Harper's Weekly*, July 25, 1868) twelve, fourteen, or sixteen hours a day. They were taken from their beds at four o'clock in the morning and started off to work before it was light, and stayed in the factory until after dark. Often they were kept awake with a whip to do their work. Many died of exhaustion. After a while a committee was appointed by the English Parliament to investigate and people were so shocked by what they learned of conditions in the factories that laws were passed limiting the number of hours that children should work.

The factory system created two classes of people. On one hand were factory owners and on the other wage earners, who only in rare instances could hope to own a factory with its costly machinery. Thus came the division of society into capitalists and workers.

In many cases the owner of a factory was seldom in the factory himself. In some factories he never saw his employees; the supervision was left to a foreman. The factory owner wanted the foreman to produce the most goods at the least possible cost. Any foreman who was too kindhearted to make the employees work as fast as possible all day long was likely to lose his job and be succeeded by someone who would get more done.

Though many of the factory owners thought little about the welfare of their employees, there were some who did. One of these was Robert Owen.

As a boy Robert Owen had been an apprentice in a mill and when he grew up he became the owner of a large factory in the heart of the factory district. The thought of the hard lot of the working people weighed heavily upon him and he determined to do what he could to help them. He built a model factory, which was light and airy. He shortened working hours and raised wages. He tore down the dirty hovels in which the factory people were living and built comfortable houses for them. He established schools for their children. Believing that the evils of his day came from competition and that cooperation should take its place, he tried to bring about this change.

For thirteen years Robert Owen carried out his ideas in his own factory. He tried to get other factory owners to do the same thing. His dream was to have around each factory a model community, where the workers owned everything in common and cooperated in all their activities. Then, thought Robert Owen, everybody would be industrious and happy, and if such communities spread, Great Britain would become a brotherhood of workers.

But Robert Owen was too advanced for his time. His new and strange ideas met with great opposition. Failing to accomplish his purpose in Great Britain, he came to this country and bought in Indiana a tract of land, which he called New Harmony. There he tried to set up a cooperative community, but unfortunately it was not a success, and after three years it had to be given up.

It seemed that Robert Owen had failed in what he had tried to do. But he had not failed, for his idea lived on in the minds of the working people of England. And after a while little groups of millworkers tried to form cooperative societies. There were many difficulties and these first attempts ended in failure. But still the idea of cooperation persisted.

During the winter of 1843 a little group of poor weavers met frequently at the Weavers' Arms in the little town of Rochdale, in the factory district of England. They talked of the bad times and the hard lot of the working people, and tried to think out a way to better their condition. They had tried to get the mill owners to raise their wages and had failed. If they could not increase their wages they must find some way to make their small earnings go further.

The opening of the first cooperative store in the world, at Rochdale, England, in 1844.

"I've got it!" cried Charles Howarth, one day, after passing a sleepless night trying to think out a plan. His idea was for the weavers to form a cooperative society and run their own store. By buying in large quantities at low prices and running the store themselves they could save the profits that had formerly gone to the storekeeper.

Other workers had tried to run cooperative stores and had failed, but Charles Howarth's plan was different from anything that had been tried before. Things were to be sold at regular retail prices and the profits of the business were to be given back to the members in proportion to the amount they spent at the store.

Full of enthusiasm, Charles Howarth called a meeting of the weavers at the Weavers' Arms and explained his plan to them.

"Save only tuppence [four cents] a week from your wages and we will make our plan succeed. It must succeed!" said Howarth.

A subscription list was passed around and twelve weavers agreed to give two pence a week from their small wages. Thus the Equitable Society of Rochdale Pioneers was launched. Charles Howarth drew up a few simple rules for the society. Later more weavers joined until there were twenty-eight members.

For almost a year the weavers saved their pennies before they had enough money to start their store. As news of the plan spread, there was much talk in the neighborhood about the "crazy weavers of Rochdale," the "penny capitalists," and the "storekeepers without a store"; but this ridicule did not stop the weavers from going on with their plan.

By the next winter the cooperators had enough money saved. One dark, dismal evening in December, after their day's work was over, the shop was opened in a narrow, mud-puddled street in the poor part of the town, called Toad Lane. Two or three weavers agreed to give their services, one acting as salesman and another as cashier.

Some of the tradesmen of the town gathered outside to have a look at the new store and wondered whether it would take away their trade.

"Aye! The owd weavers' shop is opened at last," they whispered uneasily to one another.

A noisy crowd of street urchins hooted and jeered at the weavers as they made their way to the store. But the humble workingmen and their wives kept crowding into the little shop to buy until, finally, there was nothing more left on the shelves.

At first the shop was open only on Saturday and Monday evenings, but in time the two nights became three, four, five. Only the best-quality goods were kept and full weight and measure were always given. This fair dealing made many friends for the new venture and soon the little shop was showing a substantial profit. Every member received his share of the profits in proportion to what he spent in the store.

The cooperators were better fed and better dressed than they had ever been before in their lives and their neighbors were not slow to notice the many new little comforts in their homes. So membership in the society grew steadily.

Gradually news of the undertaking spread beyond Rochdale. Branches of the Toad Lane Shop were opened in other places, and new societies were formed. By and by cooperative wholesale houses were opened to supply the retail shops with goods. In the course of time the cooperators were weaving their own stuffs, making their own shoes, sewing their own garments, and grinding their corn and coffee. Their warehouses were stocked with all sorts of goods. Within a dozen years their sales amounted to a hundred thousand dollars. Thus was proved the practical value of cooperation.

Not quite a century has passed since the Equitable Pioneers opened their little shop in Toad Lane, but today there are cooperative societies in nearly every country in the world. In our own country, especially in the states of the Middle West, the movement has grown by leaps and bounds. Many people believe that it is only when all business is carried on in a truly cooperative way that we shall be able to solve the many great problems we have in the world today.

CHAPTER V

The Quest for Power

WE HAVE seen the great difficulties under which the miners were working in eighteenth-century England to get coal and iron out of the mines. This difficulty led to an epoch-making step in the Industrial Revolution, when men discovered how to use the power in boiling water for running engines.

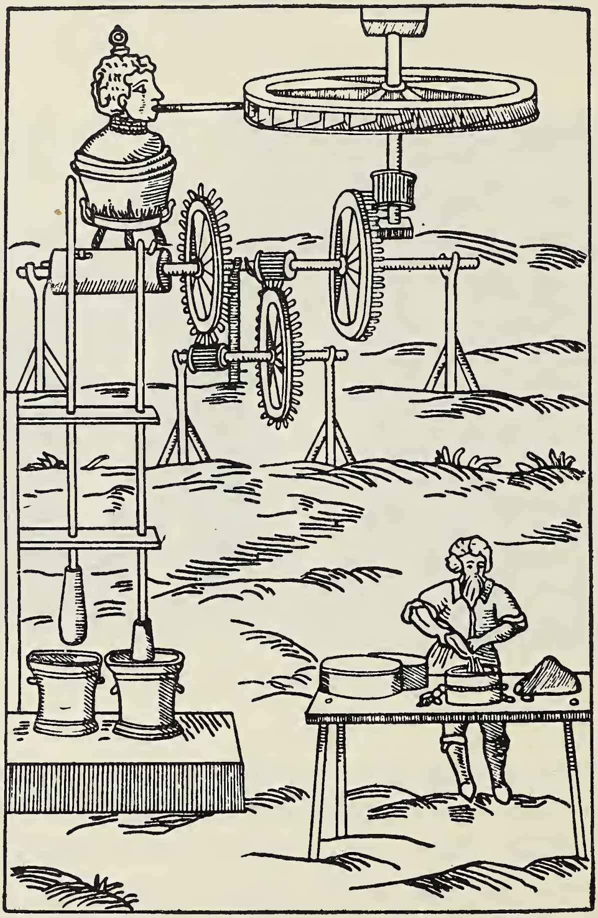
When water is heated until it boils it changes to steam. The steam needs much more room than the water did—about sixteen hundred times as much. If water is boiled in a tightly covered vessel it exerts pressure. It is because of the force in boiling water that it can be made to do work.

Men knew the power in steam for many hundreds of years before they were able to make any use of it. More than two hundred years before the birth of Christ a Greek scientist, named Hero, invented a simple device which he called the Ball of Aeolus. This was a metal globe set on a covered basin with which it was connected by tubes. At the top it had four hollow, bent tubes. When the water in the basin boiled, the steam rushed up into the globe and burst through the four bent tubes with such great force that it kept the globe revolving. The Ball of Aeolus was nothing more than a scientific toy, for old Hero never thought of connecting the tubes to rods and wheels and making the force of steam do useful work.

For almost two thousand years, experimenting with steam was merely an interesting pastime; but during the seventeenth century men's knowledge of steam made great advances. In 1601 an Italian, named Giovanni Porta, constructed a simple machine for pumping water out of a tank by means of steam. Above a furnace was a boiler which reached up into a tank filled with water. The steam, rushing from the boiler, forced the water out of a pipe in the tank.

Hero of Alexandria and his Ball of Aeolus.

In 1629 another Italian, Giovanni Branca, made a queer-looking contraption. It was a metal bust and head of a man. Water was put in through a hole in the top of the head. Fire underneath heated the water, and it turned into steam which shot out through a tube in the man's mouth and blew against a wheel so that it revolved. That wheel turned a smaller one



The curious steam engine invented by Giovanni Branca in 1629.

above it, which turned still another wheel attached to two rods. By means of the revolving wheels the rods worked up and down. Branca used his machine for pounding drugs and other things.

Otto von Guericke, a German, was the first man to show the immense power in the atmosphere. The atmosphere is exerting pressure about us all the time. As the pressure is equal in all directions it usually has no effect upon objects because the pressure on one side is balanced by the pressure on the other. But if you remove the air from one side of a body there is nothing to balance the pressure of the air on the other side. The body will therefore be pushed into the vacuum, as the space without any air in it is called, by the force of the atmosphere on the other side.

In 1650 Von Guericke invented an air pump by means of which he could make a vacuum. He made a cylinder and fitted it with a round, flat piece of metal called a piston, which fitted the cylinder just loosely enough to be moved up and down inside it. He connected the piston by a rope to an overhead pulley. In 1654 he gave a public demonstration of his air pump in his native town, Magdeburg. Twenty men were employed to hold the rope connected with the piston. Von Guericke filled the cylinder with air, and raised the piston to the top of the cylinder. Then the air was taken out of the cylinder by the air pump and the piston went down with such force that the men holding the ropes were lifted several feet off the ground.

Von Guericke followed this by another curious demonstration of the power of atmospheric pressure. With remarkable ingenuity he made two big hollow hemispheres of brass and fitted their edges together. To the outside of each hemisphere he fastened a ring to hold them by and in one hemisphere was

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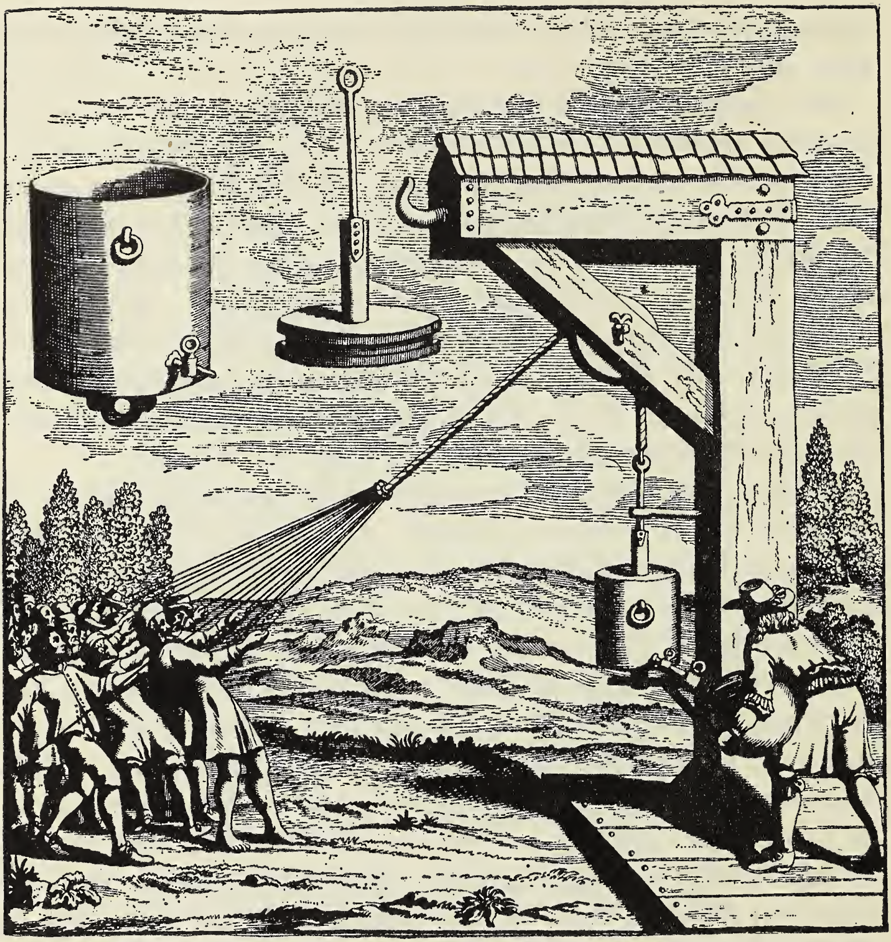


Otto von Guericke, a German, invented an air pump and in 1654 gave a public demonstration. Twenty men were needed to hold the rope connected with a cylinder. When the air was taken out of the cylinder with the air pump, the piston inside the cylinder went down with such force that it lifted the men several feet off the ground.

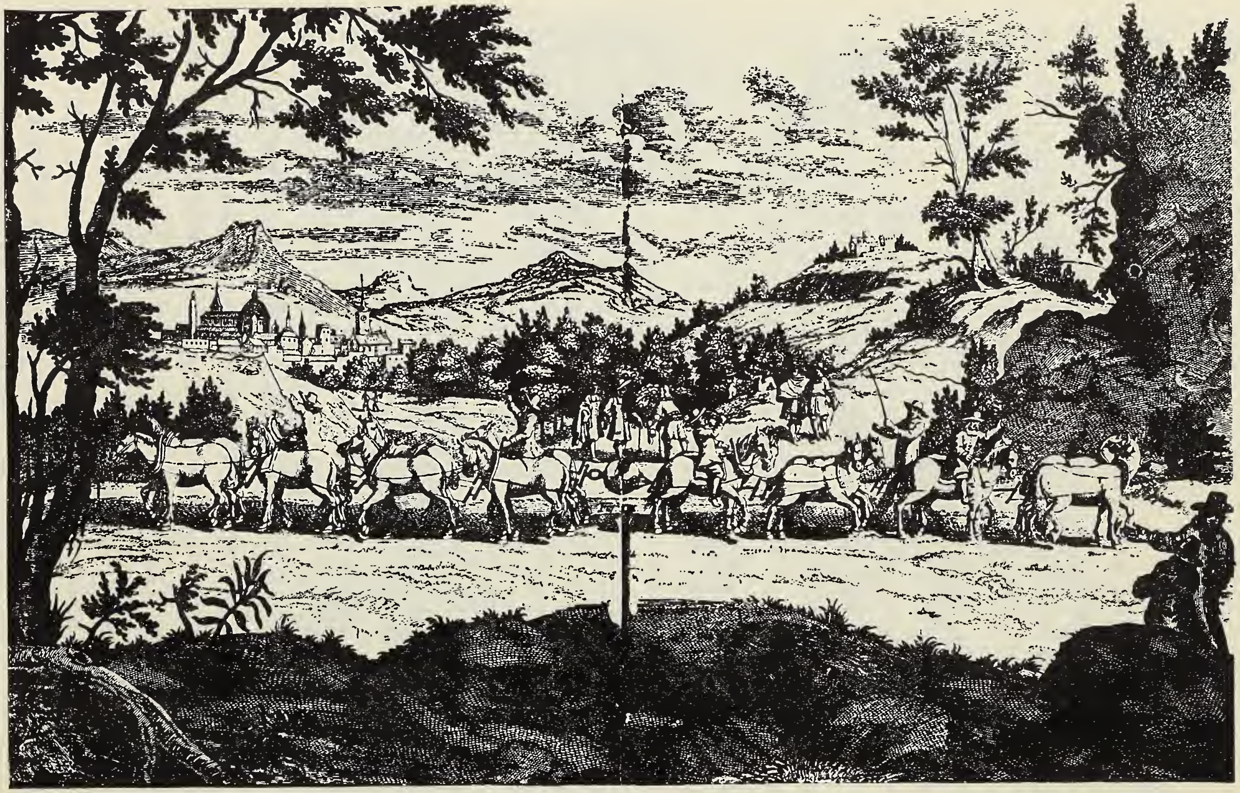
a valve connected with an air pump. With his pump Von Guericke drew out the air from inside the hemispheres. He then hitched eight horses to each hemisphere and, at a signal, one team was driven in one direction and the other team in the opposite direction, trying to pull the hemispheres apart; but they were unable to do it. Then the air was let into the hemispheres and they parted very easily.

The explanation of this strange experiment is that the atmosphere was pressing on the outside of the hemispheres, and when there was no air inside to resist the pressure on the outside the whole weight of the atmosphere had to be forced back to get the two hemispheres apart; but when there was air inside the hemispheres its pressure was balanced by the pressure of the air on the outside and the two halves could be pulled apart quite easily.

These experiments were important, because later inventors began utilizing the newly discovered force of the atmosphere.

Denis Papin, an ingenious French inventor, had observed that, in Von Guericke's experiment, air pressure lifted several men off their feet. He thought, therefore, that air could be made to do useful work. To him belongs the credit for being the first to think of using steam to produce a vacuum.

In a cylinder, open at the top, Papin placed a piston. He put water in the bottom of the cylinder, lowered the piston until it rested on the surface of the water, and set the cylinder over a fire. As the water turned into steam it needed more and more space and it pushed the piston up to the top of the cylinder. There the piston was fastened. The fire was taken away and, as the cylinder cooled, the steam condensed, leaving a vacuum under the piston. Then the piston was released and



Von Guericke made another curious demonstration of the power of the atmosphere. He made two hemispheres that fitted closely together. With his air pump Von Guericke drew out the air inside the hemispheres. Then he hitched eight horses to each hemisphere. Each team pulled with all its might but was unable to get the hemispheres apart. When the air was let into the hemispheres they parted easily.

was driven down in the cylinder by the pressure of the air above it; the descending piston raised a weight fastened to a rope which passed over a pulley. In that way air pressure did the work of lifting the weight.

At first Papin was only laughed at for his queer contrivance, but his idea of using steam to make a vacuum and utilizing the force of the atmosphere to force down a piston was made use of by inventors who followed him.

Thomas Savery, an Englishman, was the first man to apply his knowledge of steam to the problem of pumping water out of mines. Savery had often traveled about Cornwall and had seen how hard it was for the miners to keep the mines free from water.

It was an experience he had at an inn, one night, which gave Savery the idea of how to make a steam pump. He had finished drinking a bottle of wine and had tossed the empty flask into a fireplace. A little of the wine had been left in the bottle and Savery noticed that the heat of the fire had converted the wine into steam, which was coming out of the neck of the bottle. It occurred to him to see what effect would be produced by inverting the bottle and plunging its mouth into a basin of water. Putting on a thick glove to protect his hand, he seized the flask, and when he plunged its mouth into the water he was surprised to see that the liquid rushed up into the bottle and filled it.

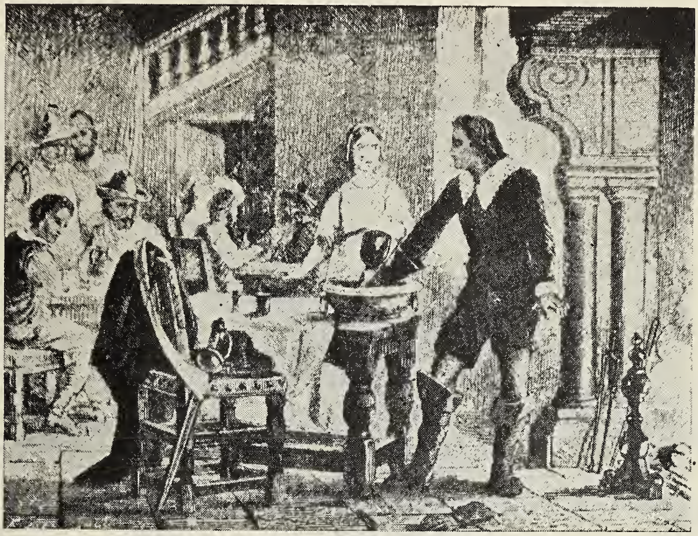
The explanation is that as the wine in the flask was turned into steam it expanded and filled the bottle. When the bottle was cooled the steam was condensed into liquid form, which required much less space than the steam. As Savery held the mouth of the bottle in the water he prevented any air taking the place which had been occupied by the steam. As a result, when the steam was condensed there was a vacuum in the bottle, and the pressure of the atmosphere on the water in the

Denis Papin demonstrating his steam pump.

basin forced the water up into the bottle to fill the space left vacant by the condensing of the steam.

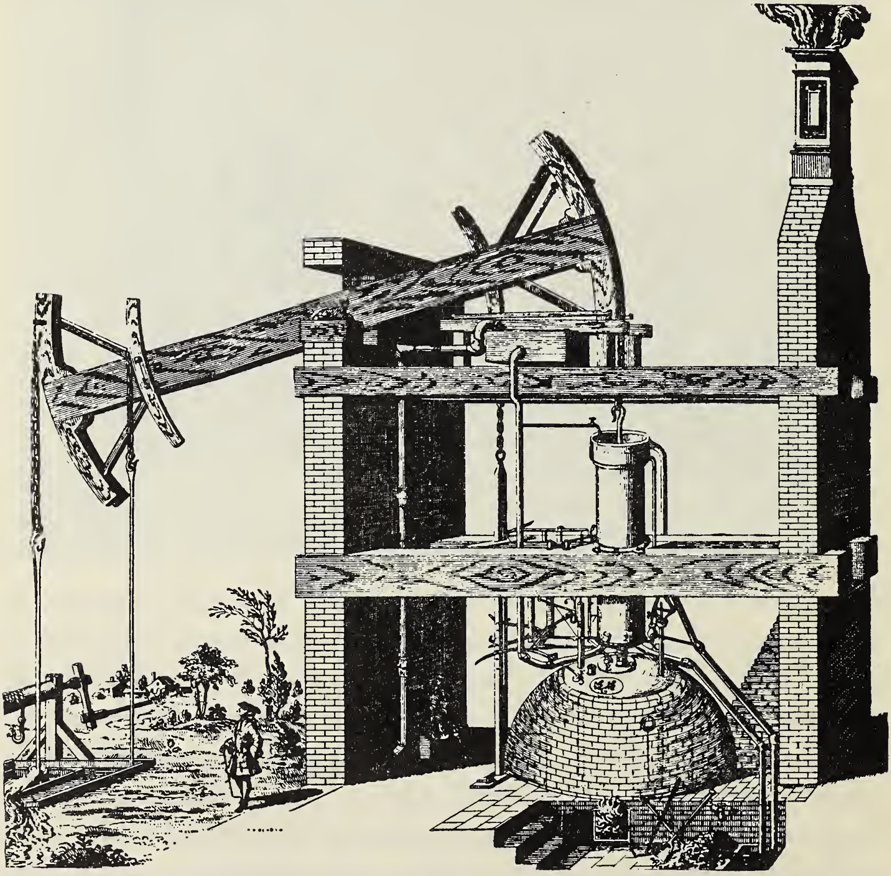
In 1698 Savery set about building an engine to pump water out of the mines, using the principle he had discovered with the wine bottle at the inn. Savery's engine was set up in a mine; but it was not a success, for it was soon found that the boiler could not stand the pressure necessary to get up enough steam to pump the water out from any great depth.

In 1705 Thomas Newcomen, an English miner, devised a pump in which he put Papin's idea to use. It had a cylinder with the upper end open and a piston which worked up and down in the cylinder. Instead of the ropes and pulleys which Papin had used, Newcomen fastened the moving piston by a rod to an overhead beam which worked on a pivot in the middle. To the other end of the beam was attached a rod which went down into the mine. A bucket was attached to the lower end of the pump rod. Steam was admitted into the cylinder beneath the piston and forced it up. The piston pushed up the piston rod; this in turn pushed up its end of the beam and made the other end go down, letting the bucket attached to the pump rod down into the mine. Then the steam below the



Thomas Savery performing an experiment which gave him the idea for a steam engine.

piston was condensed by a jet of cold water let into the cylinder. The pressure of the air above the piston forced it down; one end of the beam came down with it and the other end was raised out of the mine, bringing with it the bucketful of water which it had scooped up from the bottom of the mine. You



Newcomen's steam pump.

can easily see what an improvement such a pump was over the old ways of getting the water out of mines.

For fifty years Newcomen's pump was widely used in the mining districts of England. With it mines could be sunk much deeper than before. But running the pump used up far too much coal. Unless something more efficient than this wasteful pump had been discovered, mining would not have made much progress. It happened, however, that at this time a boy who was to solve this problem was growing up in Scotland. His name was James Watt.

It is said that Watt first became interested in steam as a child, from seeing the steam lift the lid from his mother's teakettle as it boiled on the kitchen stove. We are not sure that this story is true, but we know that as a small boy Watt was fond of tinkering with things. As he grew older he spent much of his time in his father's shop, where he had tools and a workbench of his own. There he made all sorts of things out of wood and metal. So skillful was he that the workmen often used to say, "Jamie has a fortune in his finger tips."

When Watt grew up and the time came for him to choose a trade, it seemed wise for him to follow one in which he could use his mechanical talents. So he decided to become an instrument maker. He went to Glasgow and opened a little shop. He became a friend of the professors at the university there, and they often sent him instruments to repair.

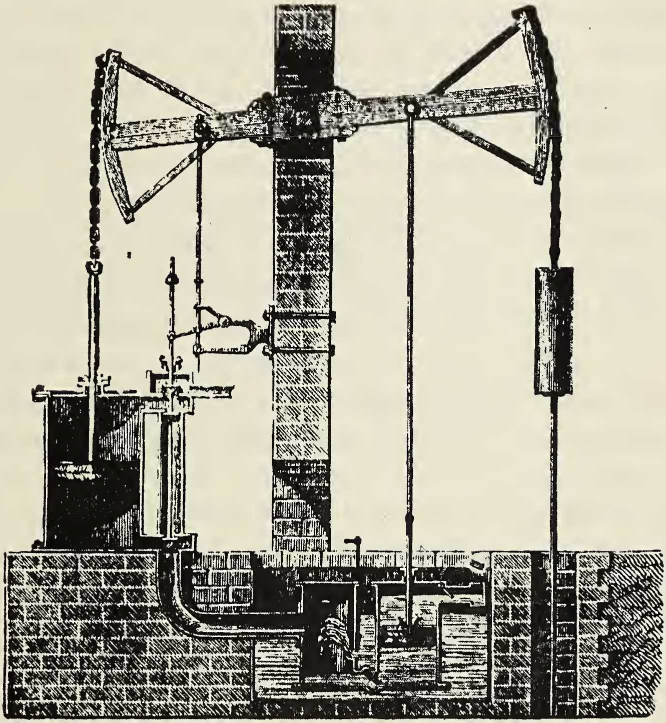
It happened, one day, that a model of a Newcomen pump belonging to the university needed repairing and was sent to Watt. As he put it in order he saw what a great amount of heat it wasted. The cylinder had to be chilled to make the piston go down, and heated again to make it rise. He realized that, in order to avoid this waste, the cylinder should always be kept hot. But how, then, could the steam be condensed and the pump made to work? Watt decided to try to find a way.

How could the steam be cooled without cooling the cylinder that held it? This was the question that haunted Watt day and night. At that time he wrote to a friend, "My whole thoughts are bent on this machine. I can think of nothing else." He tried out one plan after another, but nothing was successful. "Nature has a weak side," he was fond of saying, "if only we can find it out." So he continued his experiments.

Suddenly, one day in 1765, as Watt was out walking, the solution came to him. He would make a tank connected with the cylinder. If the air was pumped out of the tank, creating a vacuum, the steam would rush from the cylinder into the tank and might be condensed there. The tank would be kept cool while the cylinder remained hot. Watt also decided upon another important change. In Newcomen's engine the top of the cylinder was left open to enable the air to push the piston down. Watt decided to put a cover on the cylinder and to let steam into the cylinder above the piston, so that the piston would be pushed down, as well as up, by the force of the steam.

Watt set to work trying to construct a model carrying out his ideas. Day after day, month after month, he worked, and finally he completed a model. Would it work? Watt tried it and found that it would. The next step was to build a full-sized engine for a real test.

All this time Watt had been earning very little. His old business of mending instruments had fallen off and he was deeply in debt. He was in great need of money—money for food and tools and materials. Time and again it seemed that he would have to give up. It is little wonder that he was downhearted. He wrote to one of his friends: "Of all things in life, there is nothing more foolish than inventing. Today I enter the thirty-fifth year of my life, and I think I have hardly yet done thirty-five pence worth of good in the world."



Watt's engine.

But just at the time of Watt's greatest discouragement came the turning point in his life. A wealthy manufacturer, named Matthew Boulton, heard about his invention and became his partner. A workshop was set up near Birmingham, and Watt made a full-sized engine for a test and set it up in a mine. Mine owners came from near and far and saw it pump water out of the mine as they had never before seen a pump do.

Such is the story of how James Watt took Newcomen's pump and made it into a real steam engine. In all the earlier experiments with steam engines the power of steam was used only to make the piston go up. It was forced down by the pressure of the atmosphere above it. In Watt's engine, steam was made to do the whole work of raising and lowering the piston. Such an engine, utilizing the full power of steam, was capable of doing an enormous amount of work.

With the invention of the steam engine, the miners' long fight against water flooding the mines was at last won, and coal and iron could be obtained in large quantities. But the steam engine came to have a much wider use than merely as a pump in mines. It was found that it could be harnessed to the new spinning and weaving machines and thus supply the power to run them.

As machines were too heavy to be worked by hand or foot power it was necessary, before the invention of the steam engine, to build factories on the banks of swiftly flowing rivers, where the rushing water turned wheels that made the machines work. Very frequently such streams were located in inconvenient places. Often the mills had to close in the summertime for lack of sufficient water in the streams, and in winter the streams were often frozen. The immense advantage of steam power was that it could be used anywhere, so that factories could be located any place desired and work could be carried on in all seasons regardless of the weather. With its use the factory system increased by leaps and bounds.

CHAPTER VI

Fulton's Folly

BY THE latter part of the eighteenth century, with the steam engine to release the vast stores of coal and iron buried beneath the earth and to supply the power to run machines, the basis of our present industrial civilization was laid. Great expansion in industry would have been impossible, however, without better means of transporting materials than any known up to that time.

For thousands of years, from the time when the first wheeled cart was invented away back in the early days of the world, people had to depend upon slow-moving vehicles drawn by animals to carry them and their goods over the land. Through those same thousands of years, boats rowed by the strength of men's muscles or driven along by the force of the wind were used for water transportation. But sailing vessels, even the best of them, were dependent upon wind and weather. Too often storms delayed them or drove them off their courses, or they were becalmed for days because there was no wind for their sails.

The new industries, developing so rapidly at the beginning of the nineteenth century, needed a quicker, more reliable means of transportation on both land and water. Factories must be constantly supplied with raw materials or the machines would be idle. From the factories there was a steady stream of finished goods. These could not all be disposed of in the immediate neighborhood. If they could not be carried quickly to more distant markets the factories would have to slow down. With such a great need for better transportation it is not surprising that men of inventive minds should have tried to think out a way to use steam to propel boats on the water and vehicles on the land, for whenever the world needs anything badly someone is sure to appear to supply that need.

The first improvement came in water transportation. A number of inventors, both in England and America, worked on the problem but without success. Watt's engine was capable of propelling a boat if only some ingenious inventor could find the way. Then came Robert Fulton, an American inventor, who made the first successful boat propelled by steam.

From his earliest childhood Fulton had shown a talent for invention. He went to a school, in Lancaster, Pennsylvania, kept by an old Quaker. Several interesting stories are told about his school days. One day he was bent over a book in which he was drawing something. He was so busy that he seemed to have forgotten where he was. The schoolmaster stopped beside him and looked severely at the boy, who held up his work for the teacher to look at.

The drawing was well done, but the teacher said, "It would be better for thee, Robert, to spend thy time studying thy books."

"I know it, sir," answered the boy, "but my head is so full of my own ideas that there seems to be no room in it for ideas from books."

Another time Robert came late to school, and when the teacher asked him why he was late, he said, "I was making a pencil out of a piece of lead."

The teacher tried the pencil and found it a good one. The other children begged Robert to make pencils for them, too, and before many days had passed they were all using the new kind of pencil.

Robert often went out with a young friend in an old, clumsy fishing boat on a stream near his home. In order to move it the boys had to stand up in the boat and push it forward with a long pole, one end of which they thrust down to the bed of the stream. That was a very slow way of getting the boat along and a hard one, too.

One day, tired by poling the heavy boat against the current of the stream, Robert decided that the boat could be moved in a much easier way. He spent some time tinkering in the attic and before long had fashioned a sort of wheel of wooden paddles. He made two of these and put one on each side of the boat, fastening them to a long rod running to the back of the boat. The rod could be turned by a crank. The boys could sit down and turn the crank and make the paddles move. This was a much easier way of propelling the boat.

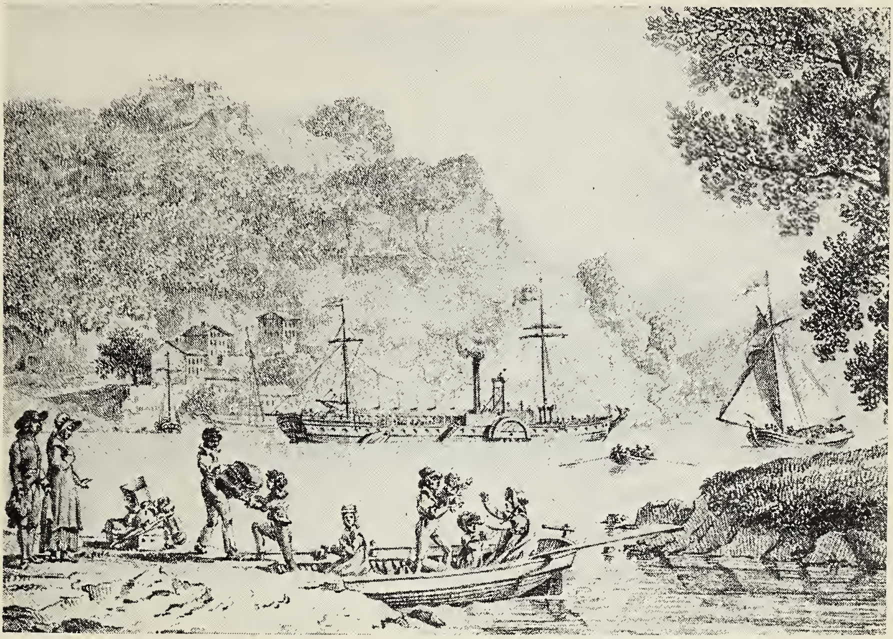
So it was on the quiet waters of a creek that Robert Fulton as a fourteen-year-old boy began working on the problems of navigation.

When Fulton grew up he decided to be an artist and went to Europe to see the many wonderful pictures there and to meet great painters. While he was in Europe Fulton met several men of science and after a while gave up the idea of being an artist and became interested in building boats. He spent several years in Paris. Robert Livingston, our minister to France at that time, was living in Paris, and he also became interested in the idea of making steamboats. He agreed to lend Fulton money to carry on his experiments, "to discover the principles on which boats should be propelled through the water by the power of steam engines."

After many trials and failures Fulton built a boat and was about to test it on the Seine River when word was brought to him that the boat had broken in pieces and sunk to the bottom of the river. The machinery had proved too heavy for the frame of the little boat. But Fulton was not discouraged. He soon had men at work raising the wreck. The machinery was put together again and a stronger boat built. When the new boat was tried in August, 1803, it steamed up the Seine River at about four and a half miles an hour and was declared to be a great success.

Fulton decided to make his next experiment on the Hudson River in New York. He bought one of Watt's engines and ordered it sent to America, and he himself arrived in New York in December, 1806. There he hired a famous shipbuilder to build a boat carrying out his ideas. When it became known that a new kind of boat was being built, crowds gathered around the shipyard curious to see it. Few people had any faith in it. "Fulton's Folly," they called it and doubted whether it would go. At last the boat was finished and Fulton named it the *Clermont*.

On August 7, 1807, a crowd of people thronged the shore of the Hudson River in New York to see the *Clermont* make its trial trip. Presently the big side wheels began to turn, sending spray flying in all directions; from the smokestack belched forth dense columns of black smoke; the machinery thumped and groaned; and the *Clermont* moved out into the river. A great chorus of cheers arose from the throng gathered on the bank. But the boat had gone only a short distance when, suddenly, it stopped. This was a trying moment for Fulton. However, he soon found the cause of the trouble and corrected it. Once more the little vessel started, and this time "Fulton's Folly" kept steadily on its way up the river.



The *Clermont* making its historic journey up the Hudson River in 1807. (From an old print in the Stokes Collection in the New York Public Library)

The *Clermont* was a queer-looking craft, as it laboriously puffed its way upstream. All along the banks of the river, crowds had gathered to see it. As night came on and they saw smoke and sparks shooting up from the smokestack, heard the growling and rumbling of the machinery and the rushing noise made by the great paddles splashing through the water, it seemed to them like some strange sea monster, breathing forth smoke and fire. One old countryman declared that he had seen "the Devil on his way to Albany in a sawmill." But in spite of its crazy looks, the *Clermont* made the voyage successfully.

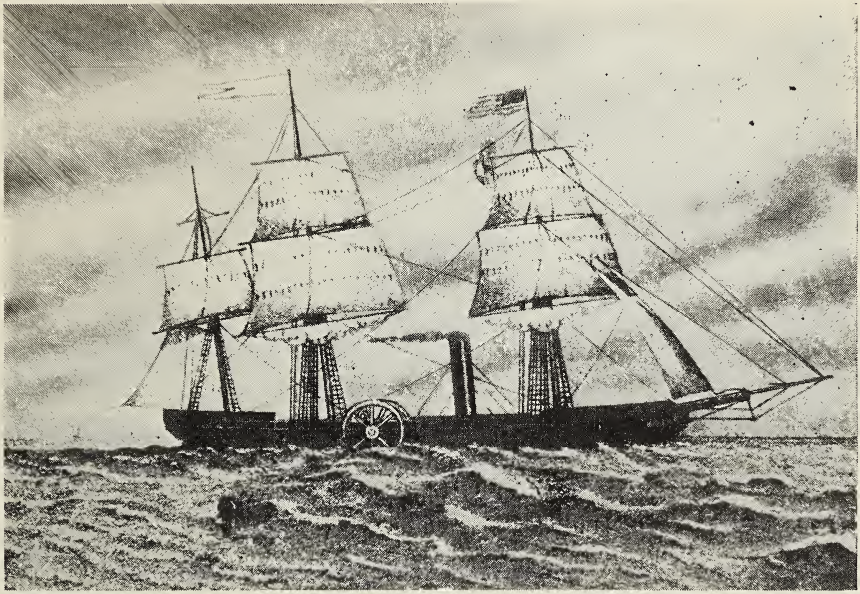
This was a glorious day for Robert Fulton and a notable one in the history of man's progress, for it marked the passing of the agelong, slow methods of transportation on the water and the beginning of a new era of speed and power. The day of steam navigation had come.

"My steamboat voyage to Albany and back has turned out rather more favorably than I had calculated," wrote Fulton to a friend. "The distance from New York to Albany is one hundred and fifty miles. I ran it up in thirty-two hours and down in thirty, and the voyage has been performed wholely by the power of the steam engine. The power of propelling boats by steam is now fully proved.

"Having employed much time, money, and zeal in accomplishing this work, it gives me great pleasure to see that it fully answers my expectations; and although the prospect of personal gain has been some inducement to me, yet I feel far more pleasure in reflecting on the immense advantage that my country will derive from the invention."

Soon after the *Clermont* made her successful trip, other steamboats appeared in rapid succession on lakes and rivers. Then a few bold spirits suggested crossing the ocean by steam.

But this was thought to be a wild and dangerous dream. Steamboats were all right for rivers and lakes, where the journeys were short and the waters comparatively smooth; but they would never do for voyages of thousands of miles across the rough, stormy waters of the ocean. All vessels used wood for fuel, and few people thought that a large enough amount could be carried for the long trip across the Atlantic.

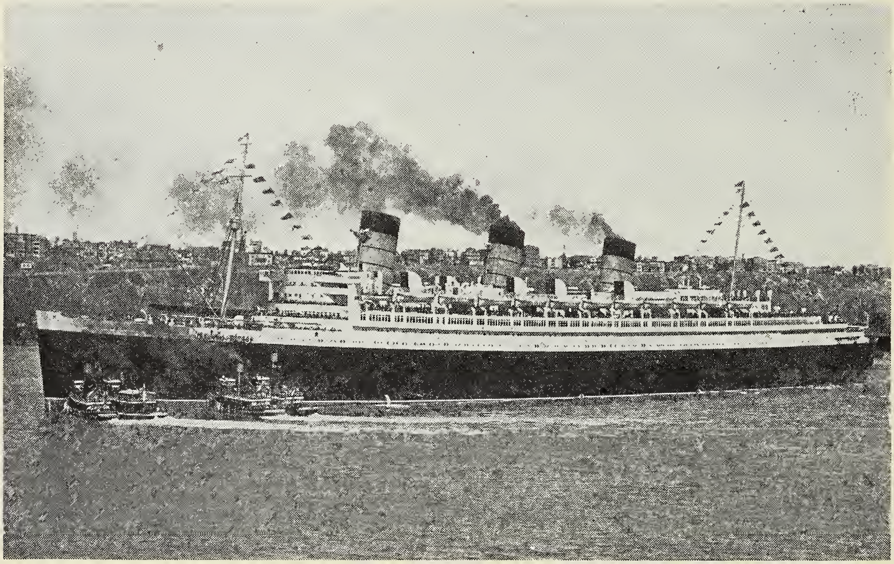


The *Savannah,* the first ship to cross the Atlantic by steam.

But there were some men ready, as there are always men ready, to risk their lives for the world's advancement. Twelve years after Robert Fulton had launched the *Clermont,* the *Savannah,* a sailing vessel, was fitted with machinery and paddle wheels for the long voyage across the sea. She left

America on May 22, 1819, and arrived in Liverpool twenty-nine days later. Through most of the trip sails were used; only now and then were the clumsy paddle wheels set in motion.

It was not until the year 1838 that two British vessels, the *Sirius* and the *Great Western,* attempted the feat of going all the way across the Atlantic by steam. The *Sirius* crossed the ocean in eighteen days, and the *Great Western,* which was much larger, arrived in New York after fifteen days. The success of these two vessels suggested to the English government the possibility of making regular Atlantic crossings, and in 1840 Samuel Cunard obtained a government contract to carry mail, freight, and passengers.



Courtesy the Cunard–White Star Line

The *Queen Mary,* a modern liner.

All the early steamships were made of wood. Wooden ships were built larger and larger, but there was a limit to their size. If they were made too large there was danger of their breaking to pieces. It was found that much larger ships could be made of iron, and that iron ships were capable of carrying much larger cargoes than wooden ships. When the invention of the Bessemer process flooded the world with cheap steel, steel replaced iron for making ships.

For years after the *Clermont* was built, all steamboats were propelled by paddle wheels. While these were satisfactory on rivers and small bodies of water, they were not suited to the ocean, because the rolling of the vessels often caused the paddle wheels to come entirely out of the water. So paddle wheels were replaced by screw propellers on ocean steamships.

Steamships brought about safe and rapid transportation between distant parts of the earth. In the old days ships were few and far between; today there is a continuous stream of ships of all kinds making their way over the ocean routes of the world. Thus, by means of water transportation, the whole world is linked together. On every ocean the ships of the leading nations furrow their way, carrying goods and people from one part to another and developing the world's commerce.

CHAPTER VII

Traveling Engines

THE invention of the steamboat gave the world better water transportation; and not long afterward men were able to apply steam to the running of locomotives, to provide better transportation on land.

The first improvements in land transportation came in the coal regions of England. With Watt's engine to pump out the water and hoist the coal, the miners there were digging deeper and deeper into the earth and bringing out more coal than ever before. But the transportation of the coal from the mines to the nearest seaport for shipment was one of the greatest problems of mine owners.

So far as we know, the first man in England to try to put a steam engine on wheels was William Murdock, assistant to Watt. He toiled early and late trying to make an engine run on wheels. In 1784 he succeeded in making a small steam locomotive. It was really only a model, but the little engine developed a speed far beyond the expectation of its inventor.

Strangely enough, Watt was not enthusiastic about the idea of a locomotive. In a letter to Boulton he wrote: "I am extremely sorry that William Murdock still busies himself with steam carriages. I wish that he could be brought to mind the business at hand and let others throw away their time and money hunting shadows." And on one occasion Watt said to his assistant: "I cannot consent to your expending good time and material in such a vain cause. Stick to your job of building and introducing our tried and proved working engines. If there were any chance of this steam carriage becoming a practical success, I should myself follow it up and develop it."

Murdock yielded to the wishes of Watt and gave up his experiments with locomotives. Other inventors made locomotives, which were used to haul coal from mines; but for one reason or another they did not work very well. In the meantime there was growing up a boy, George Stephenson, who was later to give the world the first really successful locomotive.

Stephenson's father was a fireman in a coal mine. When George was a little boy he carried his father's dinner to him in the mine. He loved to hear the engine working and watch his father stoke the great fire. It was the height of his ambition to work in the mine where his father worked, and as soon as he was old enough he became his father's assistant. Later came the proud day when, at the age of fifteen, he was promoted to be a fireman. "I am now a made man for life," said young George joyfully.

But George's ambition was to be an engineer. When he was eighteen a new mine was opened and he was put in charge of the engine. It was his duty to keep it in order and see that it worked well. George's engine became his hobby. He never wearied watching it and taking care of it. Often on Saturday afternoons, when the other workmen were out spending their week's wages, he was busy taking his engine to pieces, cleaning all the parts and putting them together again.

George heard about the wonderful engines made by Boulton and Watt and was told that they were fully described in books. But, alas! he had never been to school and could not read. Although he was almost a grown man and was working twelve hours a day, he went to night school three nights a week and learned reading, writing, and arithmetic.

Thus by work and study George Stephenson educated himself and became a skilled workman.

In 1805 Stephenson moved to a place called Killingworth, where he had charge of an engine. He had seen some of the early locomotives and realized how valuable a locomotive would be for hauling coal. He said he thought he could make a better "traveling engine" than any he had seen and set to work to build one. This proved to be the most successful locomotive yet built, but Stephenson was not satisfied with it. The next year he constructed his second locomotive, and later he built others.

Stephenson's locomotives were in constant use at the Killingworth mine, but they attracted little attention in the rest of England. There seemed to be slight prospect that traveling engines would come into general use, for news spread slowly in those days. But at length came the time when the ability of the young engineman was to be tested in a wider field.

In the year 1821 some farseeing men decided to build a railroad to carry coal from the mines near Stockton to the town of Darlington, twelve miles away. There was no thought of using locomotives on the new road; the hauling was to be done by horses.

Among the men interested in the railroad was Edward Pease. One day a stranger knocked at the door of his house.

George Stephenson had come to urge Mr. Pease to use locomotives on the new railway.

"One locomotive will do the work of fifty horses," said Stephenson, "and in time will take their place entirely."

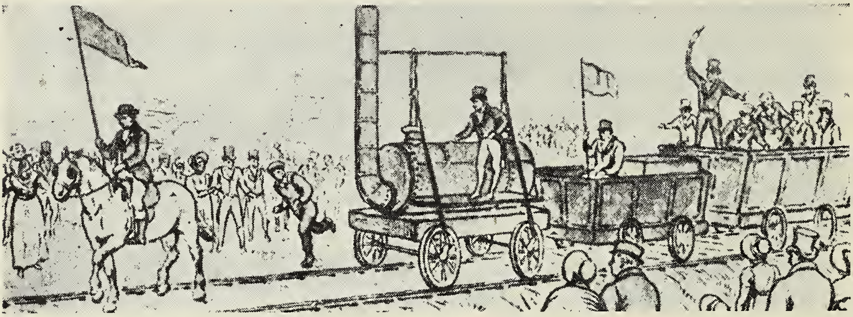
Seeing Mr. Pease's expression of surprise, Stephenson begged him to come to Killingworth to see his locomotives and judge for himself. Mr. Pease went to Killingworth and saw what Stephenson's engines could do. So pleased was he that then and there he decided to have an "iron horse," as the people of the neighborhood called the locomotive, for the new railroad.

"Here is an engine that will, before long, effect a complete change in society," he said. "If Stephenson develops the full power of that engine, his fame in the world will be equal to that of Watt."

On September 27, 1825, came the opening day of the railroad. Throngs of people gathered to see the train start. At a signal, off it went. Many of the spectators tried to keep up with it by running alongside of it.

After a while Stephenson decided to show what his engine could do. Calling to the fireman, "Keep her hot, lad," he opened wide the throttle. Clouds of black smoke belched out from the smokestack, and the little engine rocked along the track as it made its way to Darlington, sometimes at the rate of twelve miles an hour—an unheard-of speed for those days.

Stephenson's success with the Stockton and Darlington road led to his being employed for a new line to be built between Liverpool and Manchester. But there was still a good deal of opposition to the locomotive. Land owners and farmers objected to the building of a railroad near their property. The poisonous smoke from the locomotives would kill the birds, the grass, and the trees, they said. The sparks would set fire to the houses and fields along the way. The price of land would be lowered. People would be killed by bursting boilers.



Opening day of the first railroad in the world, September 27, 1825.

A committee was appointed by Parliament to question Stephenson, who had said that a train could travel at a speed double that of the fastest coach in England.

"Well, Mr. Stephenson," said one member of the committee, who wanted to show how ridiculous Stephenson's ideas were, "perhaps you could go seventeen miles an hour?"

"Yes," was the prompt reply.

"Perhaps some twenty miles might be reached?"

"Yes, certainly."

The member, smiling, continued, "Twenty-five, I dare say, you do not think impossible?"

"Certainly not impossible."

"Dangerous?"

"Certainly not."

"Now tell me, Mr. Stephenson, will you say that you can go thirty miles an hour?"

"Certainly," answered the engineer.

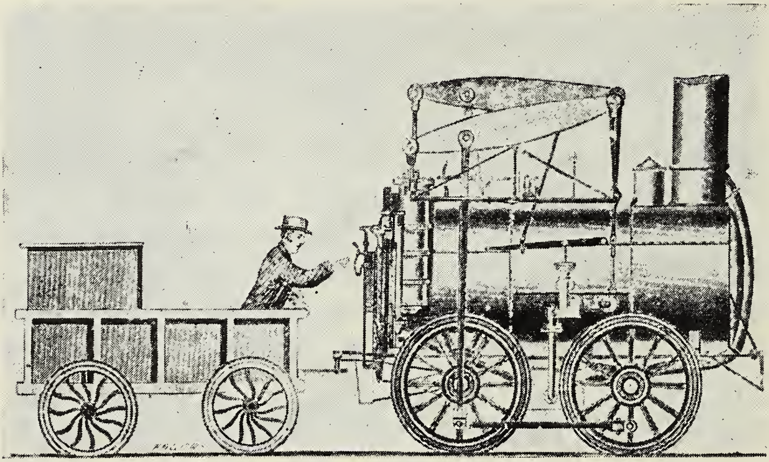
Everyone present laughed at Stephenson for making such preposterous claims for the new method of transportation.

But in spite of ridicule Stephenson never lost faith in the railroad. One day he said to his son: "I think you will live to see the day, though I may not live so long, when railways will come to supersede almost all other methods of conveyance in this country. I know there are great and almost insurmountable difficulties that will have to be encountered; but what I have said will come to pass as sure as you live. I only wish I may live to see the day, though I can scarcely hope for it, as I know how slow all human progress is, and with what difficulty I have been able to get the locomotive adopted, notwithstanding my more than ten years' successful experiment at Killingworth."

In spite of the opposition to the railroad, Parliament passed a bill allowing its construction. For four years Stephenson and his assistants cleared the ground and laid the tracks, and Stephenson built an engine for the new road. By 1830 the road was finished and opened to the public. Businessmen were delighted at being able to leave Liverpool in the morning, travel to Manchester, do business there, and return home in the afternoon. The price of coal and the cost of carrying all kinds of goods were greatly reduced.

The Liverpool and Manchester Railroad was followed rapidly by other railroads. In a very few years locomotives were busy hauling raw materials to the mills of England, carrying freight, and speeding passengers from place to place. A new era had dawned in the history of transportation. For years men had struggled to get steam power to take the place of animal power to carry them and their goods over the land and at last they had succeeded.

The news of Stephenson's remarkable success crossed the Atlantic and men in America were much interested in the new railroads. In 1829 the officials of the Delaware and Hudson Canal Company sent young Horatio Allen to England to purchase some of Stephenson's engines. There was much interest when the first one arrived in America. It was called the *Stourbridge Lion,* because the front of it was ornamented with a large, fierce-looking lion's face.



The *Stourbridge Lion,* the first locomotive in America.

On August 8, 1829, this sturdy little engine ran on a railway which had been constructed for it in northeastern Pennsylvania. Horatio Allen invited some people to ride with him but no one accepted the invitation. Then he pulled open the throttle and made his way among the hills for sixteen miles from the Delaware and Hudson Canal at Honesdale to the coal mines belonging to the company. This was the first locomotive trip in America.

Other engines were imported from England, but it was found that English engines were not suitable for America. They were too heavy and cumbersome and were continually running off the tracks. Many people thought that locomotives could not be used here. Then American engineers began building locomotives suited to this country.

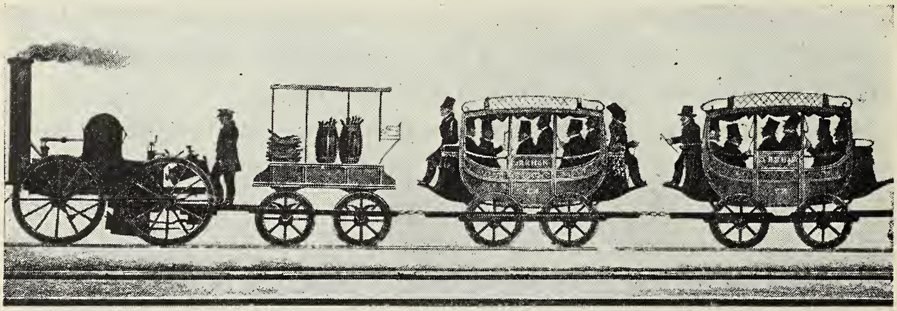
Just at that time many settlers from the Eastern states were moving west of the Allegheny Mountains into the fertile valley of the Ohio River. These people there were dependent on the East for tools and other necessities not to be had in the unsettled West. The people of the East wished to have the products of the West. Businessmen of New York, Philadelphia, and Baltimore struggled to be the first to find a way to the West to secure this trade. In 1828 the businessmen of Baltimore decided to build a railroad across the Allegheny Mountains to connect Baltimore with the Ohio River. It was to be called the Baltimore and Ohio Railway.

At first the directors planned to use horse-drawn cars. The first car, the *Pioneer,* was drawn by one horse. It was considered a great success; and for some months after the opening of the road, horses pulled the coaches along a track for the thirteen miles of the railroad that had been constructed.

A young man named Peter Cooper owned land near Baltimore and saw that if Baltimore grew to be a big city his land would increase in value. He pleaded with the men of Baltimore to consider using locomotives. In the summer of 1830 he built a small steam engine to try out on the new road in order to prove that steam power was better than horse power.

It was so tiny that he named it the *Tom Thumb,* after the famous midget.

August 28, 1831, was the day set for the great experiment. Peter Cooper invited the president of the road and other guests to take a ride with him behind *Tom Thumb.* The little locomotive did very well, speeding along the tracks at the rate of eighteen miles an hour.



One of the early trains in New York State.

In other parts of the country railroad builders were busy. The early railroads were just short lines connecting important places. Each road belonged to a different company and the width of the tracks of each company was different. This meant that locomotives and cars which could run on one company's tracks could not run on another. When traveling long distances, both freight and passengers had to be transferred from one line to the other, sometimes at great expense and inconvenience.

Since those early days the railroads have been constantly improved. Engines have been greatly increased in size and power, roadbeds have been rebuilt, safer brakes have been invented, and special cars have been devised for carrying all kinds of freight.

With the inventions of Fulton and Stephenson our modern land and water transportation systems came into being. These new and improved methods of transportation had a tremendous effect upon industries. With them raw materials could be sent speedily to mills and factories, and a manufacturer or a farmer could send his goods quickly and cheaply over long distances. This larger market for goods encouraged

Courtesy the Atchison, Topeka and Santa Fe Railroad

A modern streamlined train, the latest stage in the development of speed in railroad transportation.

production on a more extensive scale than had been possible in the earlier days. The machines were pouring out an ever-increasing volume of goods and with railroads and steamships they could be moved quickly and cheaply from one part of the world to another. New industries were developed and new markets were opened up.

CHAPTER VIII

Learning about Electricity

WHILE some men were working with steam, other men were learning about another power, electricity. The story of how man learned to control this mysterious power is a long one, beginning away back in the days of the Greeks more than two thousand years ago.

For a long, long time in the world's history men knew very little about electricity. But, little by little, they began to discover strange facts about it. By the eighteenth century it was attracting the attention of many scientific men.

In 1745 a professor at the University of Leyden, in Holland, carried on an experiment which showed that charges of electricity could be stored. Soon after this an especially made jar was invented in which a charge of electricity could be kept until it was needed. The jar was made of glass, coated inside and out with tinfoil. The electricity could be released by connecting the two coatings by a wire or some other good conductor of electricity. Because the experiment which led to its invention occurred in Leyden, this jar came to be known as the Leyden jar.

In our country Benjamin Franklin, who was a scientist as well as a statesman, became much interested in experiments with electricity which were being made in Europe. He began thinking about the number of ways in which lightning and electricity were alike: lightning travels in a zigzag line, so does an electric spark; electricity sets things on fire, so does lightning; electricity melts metals, so does lightning; animals are killed by both. He came to the conclusion that lightning was nothing more than electricity and wrote a paper on "The Sameness of Lightning with Electricity," which he sent to the Royal Society of London. The learned members of the society greeted the paper with ridicule and did not think it worth printing.

In order to prove his theory Franklin decided to try an experiment by sending a kite up into the clouds during a thunderstorm. To the kite he attached a hempen string and at the lower end of the string he tied a silk ribbon. Between the string and the ribbon he fastened a key. If his theory was correct, electricity from the clouds would come down the string and he would be able to draw sparks from the key. He would hold the kite by the ribbon, and, as silk is a very poor conductor of electricity, it would not allow the current to flow through his body.

One day in the summer of 1752, when Franklin saw that a thunderstorm was approaching, he set out with his son on a strange expedition, with his kite under his arm. When they came to an open lot near Philadelphia, Franklin let his kite fly. High up among the dark storm clouds sailed the kite. Franklin put his knuckle near the key, but, alas, there was no sign of electricity. Again and again he tried the key, but no spark came. As time passed and nothing happened, Franklin almost despaired of the success of his experiment.

The storm grew worse and worse. The sky grew darker and

Franklin's experiment in June, 1752, by which he proved that electricity and lightning were the same.
(From an old print)

darker, the lightning flashed, the thunder rumbled, the string became thoroughly drenched. The wetter it became, the better conductor of electricity it was. Not knowing whether the next moment he would be dead or alive, Franklin put his knuckle near the key and cr-a-ck! a bright spark jumped from the key to his hand, tingling and stinging. Several times he put his knuckle near the key and each time a crackling spark leaped from the key to his hand.

Franklin then took a Leyden jar which he had brought with him and, connecting the key with it, filled it with lightning from the clouds. At home in his laboratory he performed many experiments and found that with the charge of lightning which he had stored in his Leyden jar he could do everything that he could do with electricity from his electrical machine.

Franklin had drawn lightning from the sky and proved that it was electricity. Let the wise men laugh now!

For a long time the only way scientists knew how to make electricity was by friction machines, which could produce only small amounts. Then came an important step in men's knowledge, when it was discovered that electricity would flow in a current. This discovery was made in a very strange way.

An Italian scientist, Luigi Galvani, lived in Bologna. He was professor of anatomy at the university there. One day, in 1789, so the story goes, Galvani had been working on the body of a frog and had left it suspended by a thread in his laboratory. One of Galvani's assistants was working at a machine near the frog's body. Just as the electricity was going rapidly through the machine the young man happened to touch a nerve in the frog's leg with a knife and to his great surprise the leg began to move as if the frog were alive.

Galvani's wife had come to the laboratory in search of her husband, when the frog twitched suddenly and began to swing at the end of its string. Madame Galvani was so amazed at this that she hurried off to tell her husband. Galvani hastened to the laboratory. At once he set to work to seek the cause of the strange twitching. He carried on many experiments, and discovered that whenever the electricity from the machine was brought near a nerve in the frog's leg the frog would jump.

Galvani wondered whether lightning would produce the same effect. One day, in a thunderstorm, he suspended some frogs' legs by copper hooks on the balcony of his house, and he found that wherever the dangling legs touched the iron rails of the balcony the strange twitchings began. For twenty years Galvani worked at his experiments and from them he came to the conclusion that all animals were endowed with electricity.

At that time there was at the University of Pavia, in Italy, a young professor of physics, Alessandro Volta. He read about Galvani's experiments and tried some experiments with frogs himself. From these he came to the conclusion that the electricity was not in the frogs' legs, as Galvani thought, but that the movements of the legs were caused when the electricity went through the moist bodies of the frogs. The frogs merely showed that the electricity was there.

Volta realized that he was on the track of a great discovery. He began studying the effect produced when copper and iron were placed together with a layer of cloth moistened with salt water between them. Taking a number of disks of zinc and copper, he built up a pile of them, placing between each two a piece of flannel soaked in salt water. Connecting a wire with the uppermost copper disk and another wire with the lowest zinc disk, Volta was able to produce an electric current.

So the year 1800 was the beginning of the new era in electrical progress, for Volta's battery had made possible a steady current of electricity.

Another important step in man's scientific knowledge was the discovery of the connection between electricity and magnetism. From very early times it was known that there was in various places a certain kind of rock possessing the power of attracting to itself pieces of iron. There is an old Greek story that a shepherd, while tending his flocks on Mount Ida, was astonished to find that his staff, which had an iron tip, clung to a strange black stone. Although this story is probably only a legend, this mysterious stone was found in quantities in Magnesia in Asia Minor, and for that reason came to be known as magnestone, or magnet.

For centuries scientists wondered whether magnetism and electricity were in any way related; but not much progress was made until the nineteenth century, when the connection between electricity and magnetism was discovered by Professor Hans Oersted of Copenhagen.

One day, in the winter of 1819, Professor Oersted was lecturing to his students. On a table before him lay a compass and near it was one of Volta's batteries with which he had been experimenting. Suddenly the needle in the compass became excited and began swinging around and around. Oersted was much surprised at this strange happening and began to investigate the cause of it. He found that a wire carrying an electric current from the battery was near the needle of the compass. This had evidently caused the needle to turn.

For several months after this Oersted carried on a series of experiments by which he proved that an electric current passing near a magnetic needle will always make it turn around so as to lie across the path of the current.

The news of Oersted's discovery aroused great interest throughout Europe. One of the first men to hear about it was André Marie Ampère, a professor in Paris.

When Ampère was a little boy he delighted in arithmetic and used to amuse himself by doing long sums with little pebbles, which he arranged in groups. Once, when he was ill, his mother took the stones away from him. She left him alone for quite a while and on her return found that he had broken a biscuit into little bits and was using these to do sums with instead of the lost pebbles.

When he was about twelve years old, André went one day to the Abbé Daburon to borrow some books. The Abbé stared in astonishment at the boy, who was asking for books that very few grown men could understand.

"Do you know, my little fellow," he said, "that these books are written in Latin, and that differential calculus is used in them?"

The boy was downcast for a moment, for he knew neither of these. But he soon brightened up.

"Never mind," he replied, "I can learn them."

That very day André began to study Latin with his father and differential calculus with the Abbé. In a few months he was able to use the books.

When he grew up, André Marie Ampère became a professor of mathematics in the Polytechnic School in Paris. This was the man who heard of Oersted's discovery. You can imagine the delight with which he seized upon the new idea.

Ampère began experimenting along the lines suggested by Oersted's experiments. Soon he made a discovery of equal importance. He found that two coils of wire can be made to attract or repel each other by an electric current. If the current flows through the two coils in the same direction, they attract each other. If the current flows in opposite directions through the coils, they repel each other.

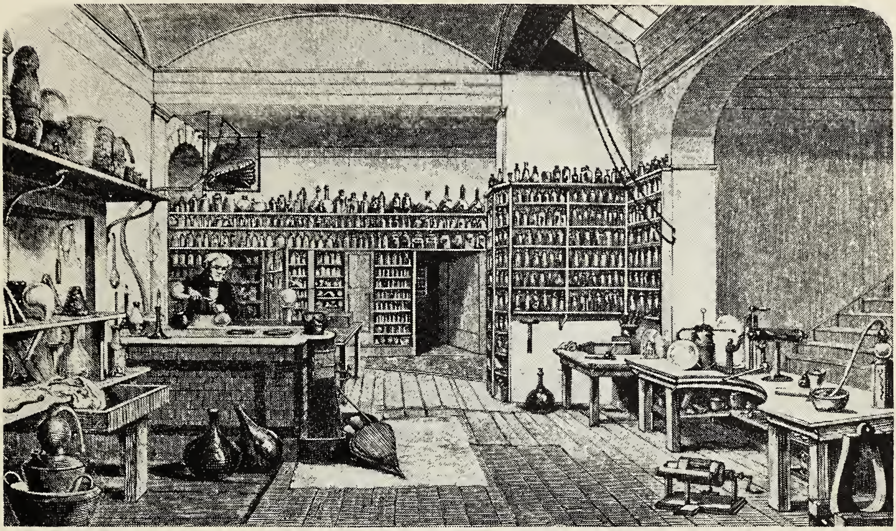
Oersted had shown that electricity can be changed into magnetism. Is the opposite true? Can a magnet produce an electric current? In the middle of the nineteenth century there came a great English scientist, Michael Faraday, who answered this question.

Michael Faraday, the son of a blacksmith, was born in the heart of busy London. When he was quite little he became a newsboy, for his father was very poor and Michael had to help support the family. No one, looking at this poor, shabbily dressed little newsboy could have imagined that when he grew up he was to become a great scientist whose work was to transform the world. Yet so it was to be.

At the age of fourteen Michael was apprenticed to a bookseller. Many interesting books were brought to the bookseller's shop to be bound and the curious boy spent every spare moment reading the books he was binding. Some of the scientific books described fascinating experiments. With the few pennies he could save, Michael bought some simple apparatus and all his spare time he spent making the experiments he had read about.

One day Michael heard that a course of lectures was to be given at the Royal Institution by the famous scientist Sir

Humphry Davy. How he longed to go! But he had no money to buy a ticket. A kind-hearted customer, however, who had noticed the boy's interest in science, gave him a ticket; and with pencil and notebook the eager youth went rejoicing to the lectures and made careful notes.

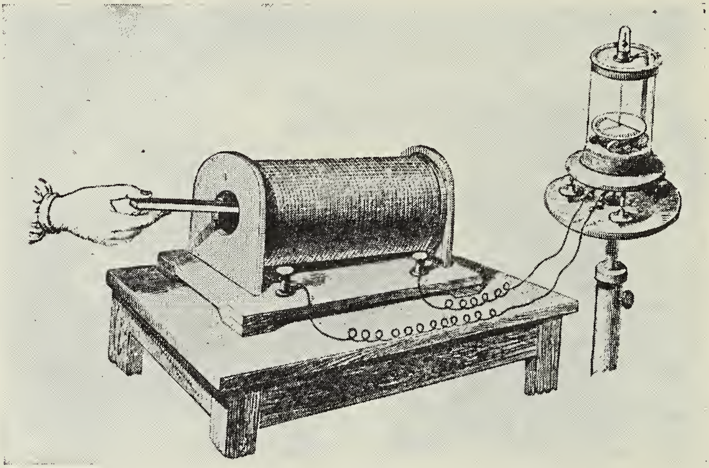


Faraday working in his laboratory at the Royal Institution in London.

Faraday took his notes home and at night, by candlelight, carefully copied them out and added drawings of the experiments. When the notes were finished he bound them into a volume with some pieces of leather he found in the shop. These notes the young enthusiast sent to the great Sir Humphry Davy with a letter expressing the wish that he might secure employment at the Royal Institution, as he wanted to be a scientist.

Sir Humphry Davy was touched by the gift from the unknown boy, and puzzled by his request. "What am I to do?" he asked one of the managers of the institution.

"Do?" replied the manager. "Put him to washing bottles. If he is good for anything, he will do it directly; if he refuses, he is good for nothing."

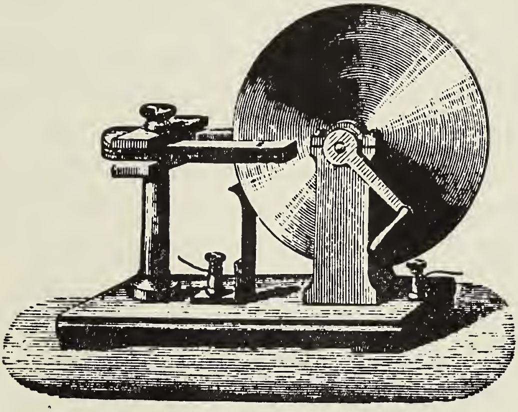


Faraday's experiment which showed the relationship between magnetism and electricity.

One night, shortly after this, just as Michael was getting ready for bed, he happened to look out of the window. What was his surprise to see a fine carriage stopping in front of his humble home! A footman in splendid livery was dismounting. He was coming to the front door! He left a note from the great scientist asking Faraday to call at the Royal Institution the following day.

The next morning Michael joyfully wended his way to the

Royal Institution and found that a vacancy had occurred in the laboratory. So Michael's wish was granted. And when, on that never-to-be-forgotten morning, Faraday was engaged to wash bottles, clean instruments, and make himself generally useful around the laboratory, there was no happier youth in London.



The dynamo invented by Michael Faraday in 1831.

Years passed, and in the course of time Faraday succeeded Davy as director of the Royal Institution. During all that time Faraday had been working, attempting to discover the relationship between magnetism and electricity. For ten years he experimented. In 1831 he wrote to a friend: "I think I have got hold of a good thing, but can't say. It may be a weed instead of a fish that, after all my labor, I may pull up."

On August 29, 1831, Faraday's efforts were crowned with success, when he made a great discovery. He coiled many feet of wire into a hollow cylinder and connected the ends of the coil to an instrument which would show whether an electric current was flowing. He brought the end of a bar magnet close to the wire. There was no current. Suddenly he thrust the magnet all the way into the coil of wire, and the needle in the instrument showed that there was a current in the wire.

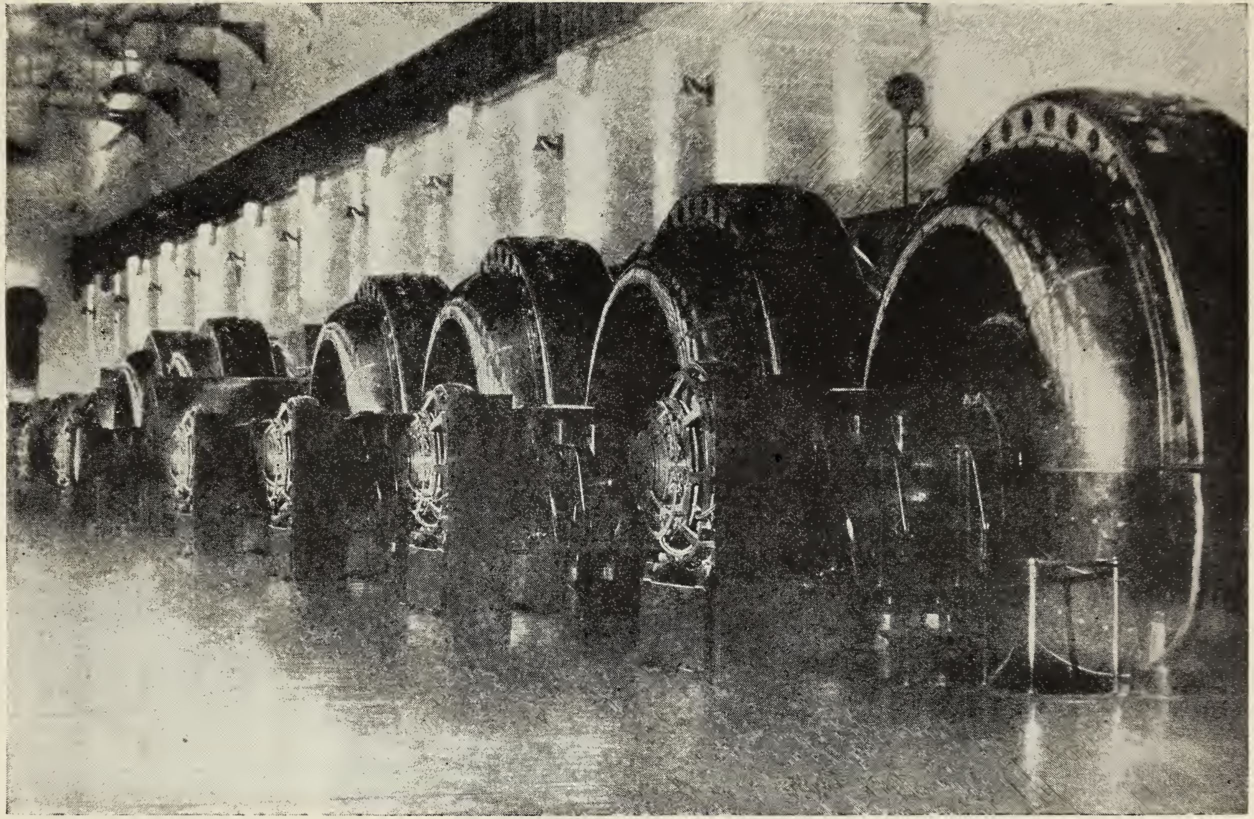
"There it goes! There it goes!" shouted Faraday excitedly.

But the current stopped again when the magnet came to rest. Quickly Faraday jerked the magnet out of the coil and, as he did so, the needle moved in the opposite direction. Again and again he repeated the experiment; and each time the magnet was thrust in and out, the needle swung back and forth, coming to rest when the magnet was still. Thus it was that Faraday discovered how to produce an electric current with a magnet.

How to get electricity from a magnet in large quantities? That was now the problem. Faraday decided that he must make a machine which would generate electricity. Twelve days later he had succeeded in constructing a simple machine consisting of a copper disk with a handle fitted to it and a big horseshoe magnet. Between the poles of the magnet he revolved the copper disk and connected it with a galvanometer. This was the first dynamo.

As the earth itself is a gigantic magnet there is no end to the supply of magnetism. When magnetism is turned to electricity by a dynamo an endless current of electricity can be obtained. Thus Faraday's dynamo unlocked an inexhaustible supply of power.

Later inventors worked to increase the usefulness of the dynamo. In Faraday's dynamo the current was produced by



Courtesy Niagara Hudson Power Corporation

Faraday's dynamo has grown into the monster dynamos of today.

Courtesy General Electric Company

A modern power station. A dam has been built between two hills. Water from above the dam drops down through the big pipes into the powerhouse. The force of the falling water turns dynamos inside the powerhouse, generating electricity.

turning a handle. But it was soon discovered that the power of swift-flowing water, which, for many centuries, had been used to turn water wheels, could be made to turn wheels that would produce electricity. From Faraday's simple machine has grown the modern generator by which electricity can be produced cheaply in quantity.

Electricity has an advantage that no other form of power has. It can be used far from the place where it is made. In the early days of the use of electricity no one had learned how to transmit it from power plants to faraway places. Then engineers solved the problem of sending it over long distances. After that, many small communities, each of which had formerly required its own generating plant, were connected and received their supply of electricity from one central power station.

Today the power which the huge dynamos produce can be carried for hundreds of miles. From these machines, hidden away in some remote powerhouse, comes the electric current to light our streets and buildings, to provide the power for factories, to run streetcars and trains, and to perform a thousand services in our homes.

CHAPTER IX

Striking Oil

MEN had discovered the power in steam and in electricity. Then, in 1859, was discovered another power—the power that is in petroleum, or "rock oil," as it was first called.

Many scientists think that oil was formed from water plants and the remains of fish buried under the surface of the earth in the very early days of its history. The seas of the early world swarmed with all kinds of creatures. During those ages terrible earthquakes often crumpled and twisted the earth's surface, and the ocean bed was violently shaken. At such times countless millions of fish and sea plants were destroyed, and their remains were buried beneath the surface of the earth.

As ages passed, the sand and mud under which the sea creatures were buried became very deep; in time they were changed to rock, which pressed down upon the remains of the ancient plants and animals. Crushed by the weight of the rocks above them, these gave out a great deal of oil, which collected in pools. Thus, slowly, through many ages, the plants and animals of the early world, far beneath the surface of the earth, were turned into thick, dark, jellylike oil, sometimes called petroleum.

This process may have gone on very generally all over the world. In the course of time the oil probably soaked through porous rocks and today it is found only in those places where there are certain kinds of rock through which it could not make its way. In such places it remained imprisoned beneath the rocks, where it collected in pools. When the oil was pressed too hard it sometimes jetted up between rocks and through the soil to the surface. Sometimes it seeped up through crevices in the rocks or bubbled up in creeks.

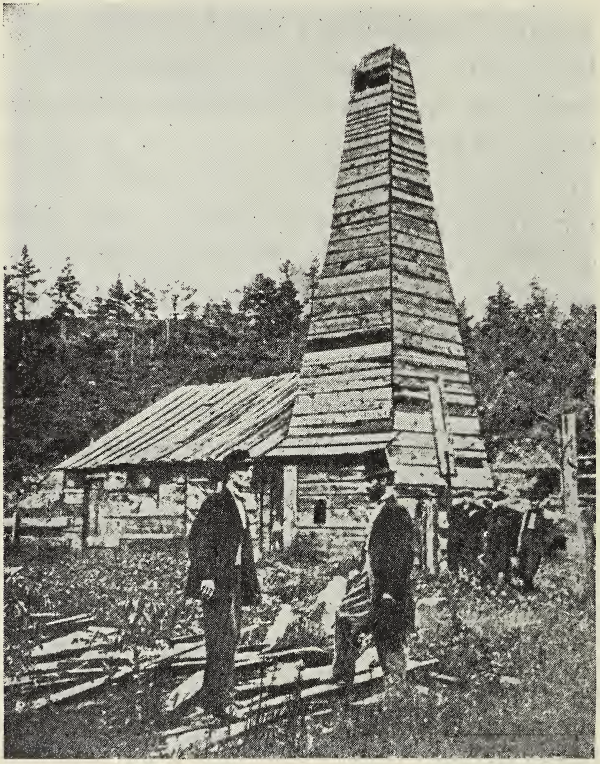
The existence of petroleum, or rock oil, in various parts of the world had been known from the earliest times. The Indians in our country used it to rub on their joints to cure rheumatism. They collected it from streams, where it floated on the surface of the water, by dipping blankets into the stream, letting them become soaked with the oily scum, and wringing out the oil into gourds. From the Indians the early settlers learned its value.

In northwestern Pennsylvania oil floated in such quantities on a little stream that it was called Oil Creek. An enterprising businessman, named Samuel Kier, built up a business of bottling this oil and selling Kier's Rock Oil as medicine.

In 1854 George H. Bissell, a New Haven businessman, became interested in oil. He purchased a large tract of land at Titusville near Oil Creek, and formed the Pennsylvania Rock Oil Company. Thus came into existence the first oil company in the world.

Bissell saw that there was a fortune for the man who could obtain oil in large quantities. But how could this be done? Certainly not by dipping it from the surface of streams. He came to the conclusion that under the surface of the earth were pools of oil and that by drilling down through the rocks he might reach the oil and could pump it up.

Bissell sent Edwin L. Drake to Oil Creek valley to attempt the new method of getting the oil out of the earth. Drake was a firm believer in the enterprise and put all his savings into it. "Underneath this little town of yours," he said to the people of Titusville, "is a storehouse of wealth—wealth greater than that of the Indies." But the people only laughed at him for having such foolish ideas.



The first oil well in the world, drilled near Titusville, Pennsylvania, in 1859 by Edwin L. Drake.

Drake hired Uncle Billy Smith, who had had experience in drilling salt wells, and his two sons, Sam and John, to help him. His plan was to dig up the earth until he reached solid rock and then drill until he tapped a pool of petroleum.

The men began digging with pick and shovel on the banks of Oil Creek. Fifteen feet down the walls caved in, but props were inserted and the digging went on. At thirty-six feet, solid rock was reached and drilling was begun. It was slow work. The drill bored deeper and deeper into the rock, but no oil came forth.

Day after day people gathered about to watch the men drilling at the rate of a few feet a day, hoping to reach oil which might be hundreds of miles down under the earth. "Drake's Folly," they called the well.

But week after week, in spite of one disappointment after another, the men kept on drilling. On August 27, however, after they had reached the depth of sixty-nine feet and nothing had happened, they stopped work and went home discouraged.

The next morning Sam Smith, Uncle Billy's son, strolled out to the deserted well and peered down into the deep hole. It was full of black, oily liquid, bubbling and frothing!

"Oil! Oil!" he shouted in great excitement. "We've struck it!"

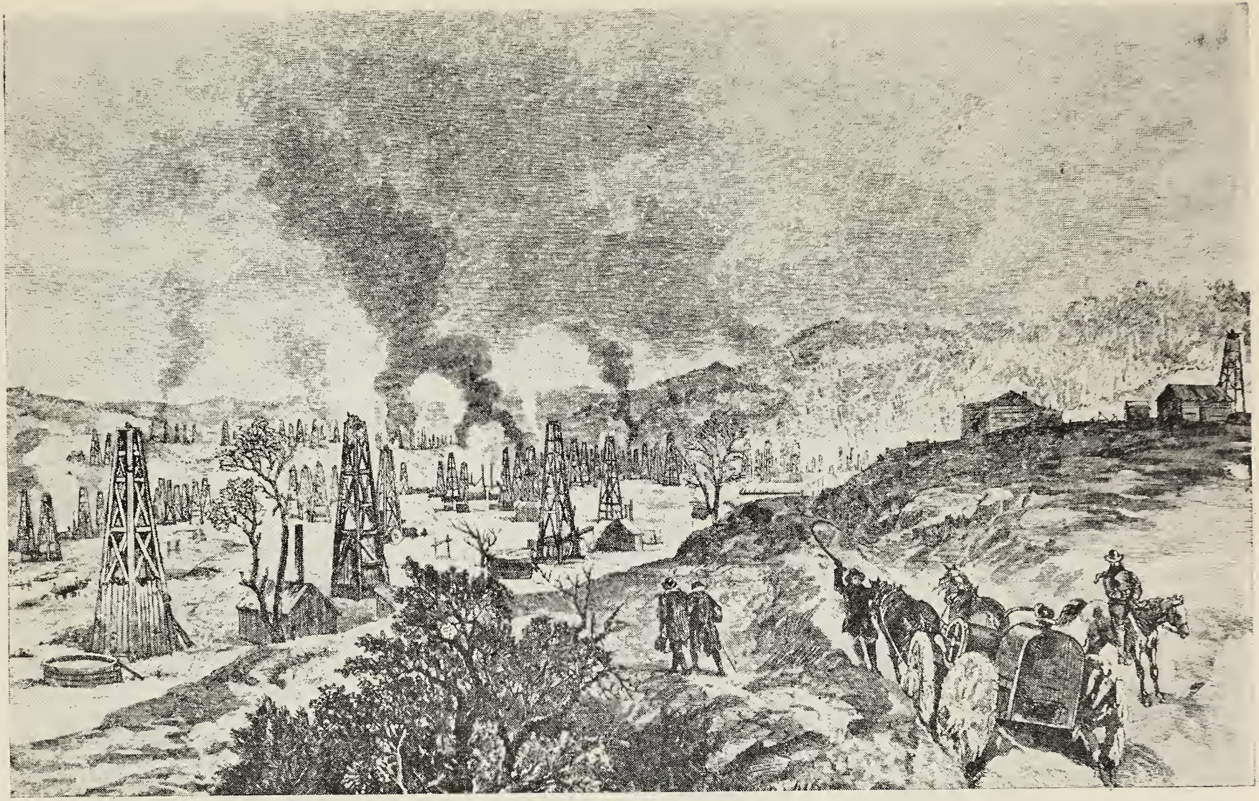
Success at last! Drake and his helpers quickly rigged up a simple pump and began to pump up the dark liquid. They filled everything they could lay their hands on with the oil. And still it came. Then Uncle Billy mounted a mule and started for Titusville to tell the people there that "Drake's Folly" was not so foolish after all.

News of Drake's success spread rapidly. Thousands of people realized that a new source of wealth had been found, and rushed to western Pennsylvania to buy land near by. Farms that had been considered worthless sold for fabulous sums. Teamsters arrived in droves. Their wagons churned the roads into oily mud as their leaking loads spilled and splashed on their way to the railroad station. Hundreds of flatboats, laden with barrels of oil, floated down Oil Creek.

Poor clerks and laboring men gave up their jobs and swarmed to the spot where fortunes were to be made so easily. Companies were formed, and stock in these companies was offered for sale. Many new wells were drilled and oil began to flow in larger and larger amounts. Thus a new industry was born.

Sometimes oil was struck and fortunes were made. In other places oil was not found, and many of the unfortunate investors lost everything they had. Geologists made a careful study of the rock which contained the oil and were able to tell where it could be found. But the oil speculators would not heed their warnings, and many of them put their money into mere holes in the ground.

The pools of oil often lie very far down under the surface of the earth. A tall tower latticework is built above the place chosen for drilling an oil well. To the top of this derrick are fastened the pulleys over which the ropes that operate the machinery are to pass. An engine is placed near the foot of the derrick and covered with a rude shed. The engine is attached to a machine called a walking beam, which is used in working the drill. The walking beam is a large lever balanced on an axle at its middle point, having one end attached to the engine and the other to the drill. By this means the engine



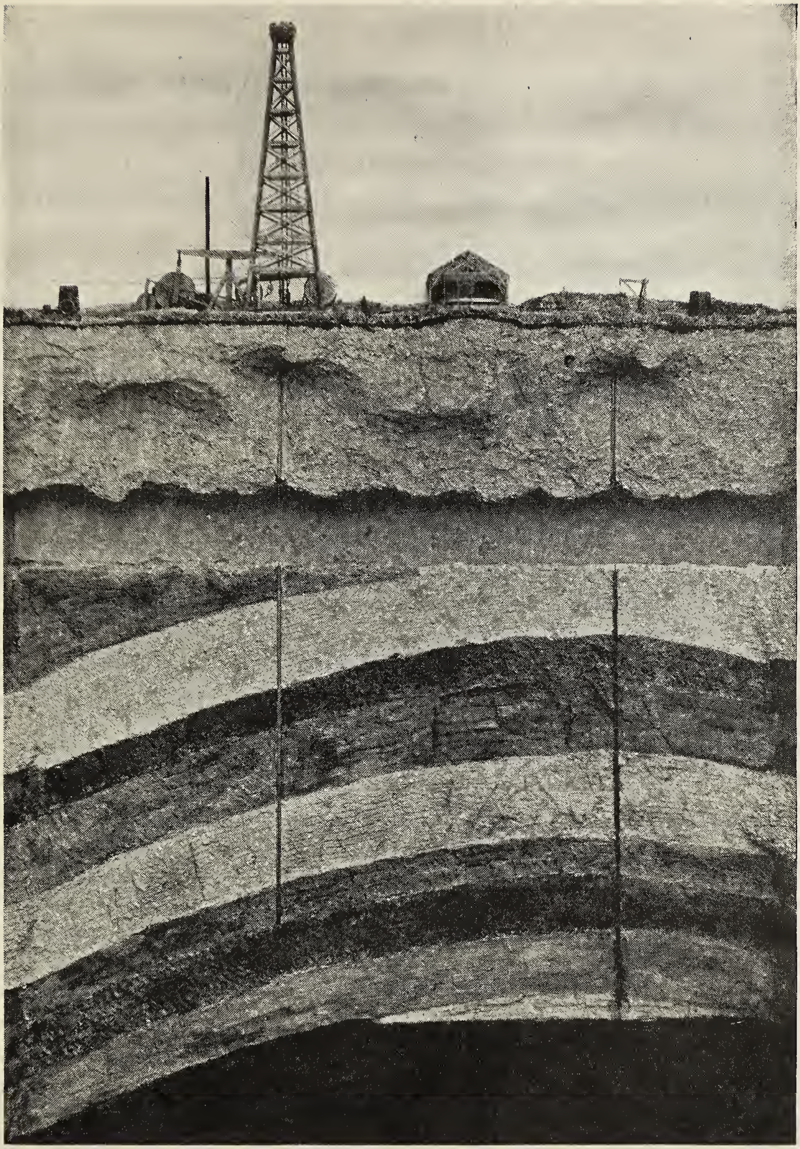
Oil Creek valley as it looked shortly after the discovery of oil there. (From *Frank Leslie's Illustrated Newspaper,* January, 1865) drives the drill and the drill bores its way down through the rock.

In most cases pumps are required to force the oil up to the surface, but sometimes, when drillers strike the oil pool, the oil rushes up through the pipes and spouts hundreds of feet into the air like a fountain. This is called a gusher. Where oil is plentiful many wells are drilled. Sometimes the derricks in these places are built so close together that the oil field looks like a forest with tall derricks instead of trees.

The oil, as it comes from the earth, is thick and dark. It contains many impurities which must be removed before it is suitable for use. The removal of these impurities and the separation of the various substances found in the crude oil is called refining. By this process the sticky, dirty-looking oil is transformed into kerosene, gasoline, naphtha, and other useful products.

First the petroleum is heated in a great tank to the temperature at which one of the products contained in it will turn to vapor. As this vapor passes through cooled pipes it condenses into liquid, which flows down into another tank. Then the tank containing the remaining petroleum is heated to a higher temperature. With this greater heat another product in the petroleum is changed into vapor, drawn off, and condensed. The process of heating the tank of petroleum to higher and higher temperatures continues until all the products in the petroleum have been transformed into vapor. When all these have been taken off there remains a heavy, black, tarlike sediment. This is the oil which is used to run ships and locomotives and to heat buildings.

The first widespread use of oil was to give the world a new



Courtesy Field Natural History Museum

If we could cut through the earth below an oil well to look at the formation, we should probably see something like this. At the bottom is the pool of oil and above it are layers of different kinds of rock.

light. Before this, candles and whale-oil lamps were the only means people had of lighting their houses. Candles were tedious to make and gave poor light. Oil, made of the fat of whales, gave a better light; but whale oil was expensive because it was becoming hard to get.

From New England hardy crews set out on long, dangerous voyages, searching the sea for whales. These animals had been hunted to such an extent that they were hard to find. Only after months, and sometimes years, did the ships return with great casks of oil, made from the blubber of the whale. People were beginning to wonder what they would do for light. The discovery that rock oil would burn and give a good light relieved anxiety about illumination and gave people a substitute for whale oil that was much cheaper and better.

For nearly twenty years after Drake's discovery Pennsylvania furnished all the oil in the United States. Later, wherever oil springs were known, wells were bored. Rich oil fields were found in Ohio, West Virginia, Texas, Oklahoma, Kansas, California, and other parts of the United States. Oil was also found in other countries. Next in importance to the United States is Mexico, which supplies the world with one quarter of its petroleum. There are also great quantities in South America, Persia, Mesopotamia, Russia, and other places.

From 1860 to 1900 only small amounts of oil were produced. But during those years the gas engine was being perfected, and after 1890 oil was used successfully to run automobiles. Within a short time it became the second most important power resource of the industrial world.

With the increasing use of oil the transportation of the petroleum from the oil fields to the refineries presented a difficult problem. The great oil fields were hundreds of miles away from the industrial region where most of the oil is refined. How was the tremendous quantity of oil to be shipped over such a great distance? At first it was put in barrels and sent by wagons, trains, and ships. But these methods were expensive and slow. Some better means of transportation had to be found. In time tankers were constructed for carrying oil on the water and tank cars for transporting it on land.

The most marked advance in transportation was made when the oil companies decided to lay pipes from the oil fields to their refineries, far away in the large cities. Today a network of pipe lines underneath the ground joins the oil fields with cities on the Great Lakes, the Gulf of Mexico, and along the Atlantic Coast. They are constructed of strong iron tubing, so they will withstand great pressure. Engines are placed at intervals to pump the oil through the pipes. By this means oil can be transported quickly and cheaply.

Modern industry is becoming increasingly dependent upon oil. One of its by-products, gasoline, is used in running automobiles, airplanes, and airships; another, fuel oil, propels many great ships and also furnishes the power for some of the locomotives on our railroads. Manufacturers in many industries have begun to use oil-burning engines in their factories. Oil keeps the wheels of machines and engines turning smoothly. Today, everywhere, all over the world, men are searching for oil. Steadily the drilling goes on, and tankers carry the precious oil to all the industrial nations of the world.

CHAPTER X

Kelly's Kettles

UP TO the middle of the nineteenth century, machines, locomotives, rails, bridges, ships, and many other things were made of iron. But a stronger material was needed for the great constructions that were beginning to come into use.

For many centuries men had known how to make steel, which they made by burning the impurities out of iron. The smiths of early times could make swords of steel which were so flexible that they could be bent almost double without breaking. The knights of the Middle Ages wore steel armor and carried steel weapons. But good steel, made by the only methods known, was very expensive. By the middle of the nineteenth century some way of making steel at less expense was greatly needed. Who would invent a process of making steel quickly in great quantities, and so reduce the cost?

Early in the history of our country deposits of iron were discovered in various places; and there were little iron furnaces in many states, where ironworkers made iron stoves, pots, shovels, plows, and other useful things.

About the middle of the nineteenth century there was living in western Kentucky an ironworker named William Kelly. Kelly had a small furnace, and, like all the ironworkers of the day, used charcoal to refine iron. In his furnace he put layers of charcoal between layers of pig iron. A blast was turned on and more charcoal was added until the iron was purified. This process used up such quantities of charcoal that all the wood near his furnace was burned up. The nearest source of more charcoal was several miles away, and if charcoal had to be brought from a distance it meant loss of money.

Just at this time Kelly happened to make an important discovery. One day, in 1846, he was melting iron in his furnace in the usual way when he noticed something which excited his curiosity. At the edge of the molten iron he saw a blinding white flame. Kelly went nearer his furnace to look more closely. He was surprised to find that there was nothing there but a blast of air. What a strange thing! Then, in a flash the explanation came to him. The iron contained carbon. When the air blew on the iron, the oxygen in the air united with the carbon in the iron and the blast blew them out. There was no longer any need for the slow, tedious process of burning the impurities out of pig iron with charcoal; a blast of air would refine the iron and convert it into steel.

Kelly was greatly excited and ran to tell his neighbors the good news. But most of them laughed at the idea. Make steel with cold air? The idea was ridiculous. Then Kelly invited a number of ironworkers to his furnace and gave a demonstration. He blew air into some molten iron and, to the amazement of everyone, the metal grew white hot. A blacksmith who was near by took a piece of the hot iron, tossed it on an anvil, and hammered it into a horseshoe. With another scrap of iron he made nails, and then he shod a horse that stood near. Thus Kelly had proved that a blast of air would refine pig iron, for pig iron cannot be hammered. But still the ironworkers were unconvinced.

"Some crank'll be burnin' ice next," said one of them.

One of Kelly's customers, hearing that he had adopted a new way of making iron, wrote: "We understand that you have adopted a newfangled way of refining your iron. Is this so? We want our iron made in the regular way or not at all."

Kelly's father-in-law who had lent him money for his ironworks threatened to withdraw it. "Come down to earth and conduct your business in a safe and sane fashion," he said, "or I'll ask you to pay back the money I lent you."

So Kelly took his machinery into an out-of-the-way place in the woods and set it up there. No one knew about this secret spot except the ironworkers whom Kelly had brought with him to help him. By 1851 he had built a specially constructed vessel called a converter, which was like a huge caldron. In the bottom were holes to let in a blast of air. It was mounted so that it could be turned over and emptied. One improvement followed another. In all, Kelly built seven converters in his backwoods hiding place.

In the year 1857 there was a financial depression and Kelly had to give up his ironworks. He went to the Cambria Iron Works at Johnstown, Pennsylvania, and secured permission to make experiments there. Soon he had built a converter and was ready to make a public demonstration of his new process of making steel. A crowd of workmen gathered around to see the queer-looking contraption of the "Irish crank."

Kelly told the engineer that he wanted the strongest blast of air he could blow into the converter, and the engineer, for a joke, blew such a strong blast that the entire contents went flying out in a shower of sparks. The workmen roared with laughter at "Kelly's fireworks."

A few days later Kelly was ready for a second demonstration. Again a blast of cold air was forced through the molten iron in the converter. Then Kelly poured out the contents. Taking a small piece, he cooled it and hammered it into a thin plate on his anvil. Once more he had proved that iron can be refined with cold air.

Kelly remained at Johnstown for five years. In time he was honored and rewarded for his work. "Kelly's Kettles," as the converters were called, were sold in great quantities, and Kelly became a rich and successful man.

In 1856 Henry Bessemer, an English ironmaker, made a discovery similar to Kelly's. Bessemer became convinced that the greatest need of the time was a cheap method of producing steel in large quantities. He fitted up a shop and made many experiments, but without much success.

One day when he was working with his furnace he noticed that two pieces of pig iron did not melt, although the heat of the furnace was very great. About half an hour later he saw that the iron pieces were still unmelted. It occurred to him to take out one of the pieces and examine it. To his surprise he found that what he had thought was a piece of unmelted iron was steel. From this experience Bessemer, like Kelly, realized that if air was forced into the molten iron the iron would be changed to steel.

Bessemer built a small converter, open at the top, with a number of small holes in the bottom through which to blow air. He connected it with a powerful blast engine. When all was ready he told the workmen to pour melted iron into the converter. At a signal the blast of air was turned on the hot metal. There was a deafening roar; a sheet of flame and a shower of sparks shot high up into the air.

Explosion followed explosion. No one dared go near enough to the converter to shut off the blast of air and examine the metal. But at last the flame died down and the workmen found, to their great delight, that they had steel of very good quality.

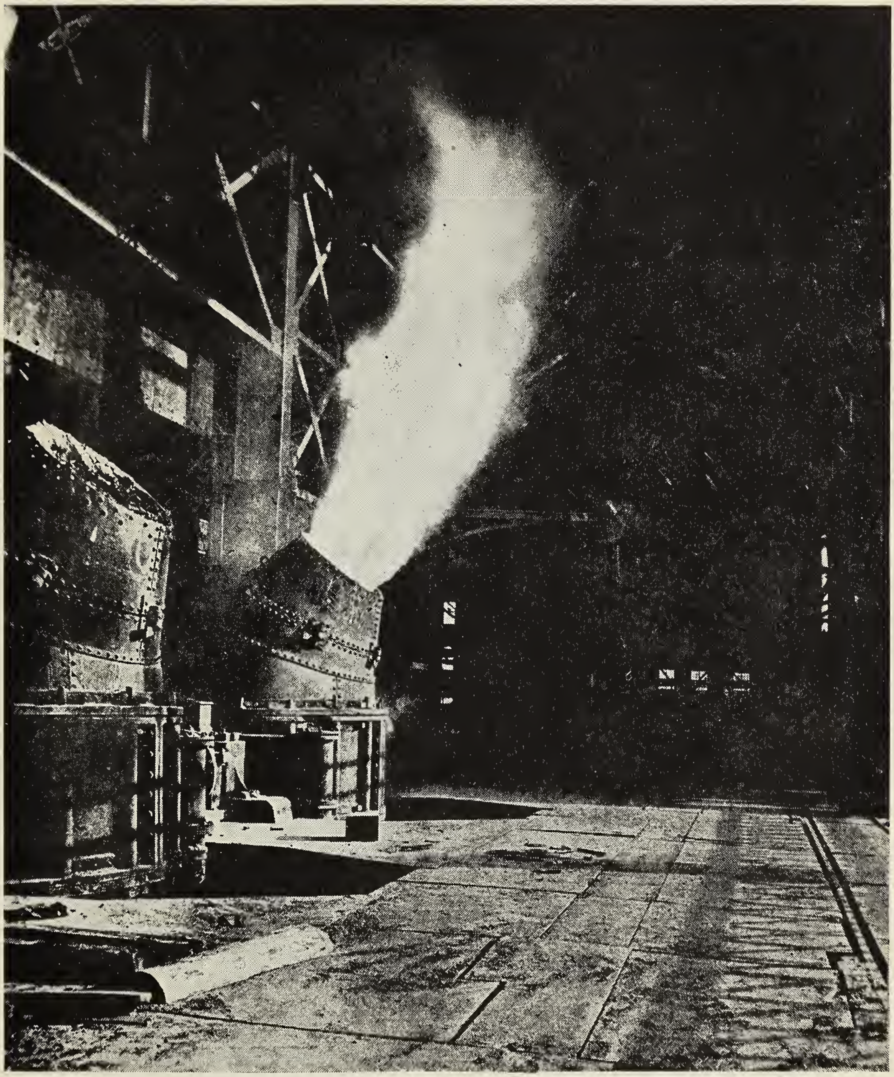
Bessemer then wanted to put the new process on the market. But he met with as much opposition in England as Kelly had met with in America. One day, shortly after his discovery, he was to read a paper before a meeting of ironmakers, entitled "The Manufacture of Iron without Fuel." It was the subject of many a joke.

"Clay," said one ironmaker to a friend, "I want you to come with me to the meeting this morning, for we shall have some good fun. Do you know there is actually a fellow going to read a paper on making steel without fuel? Ha! Ha! Ha!"

But, in spite of ridicule, Bessemer's paper caused a sensation, and ironmakers flocked to see the new process. Bessemer sold them licenses, which gave them the right to use his process, and he soon began to reap a fortune.

Then, alas! disaster came as swiftly as success had come. Ironmakers found that the new process would not work. Day after day fresh reports of failures came in to Bessemer. He was stunned. He went around to the different furnaces and saw for himself that the quality of steel turned out by his process was very poor. Something must be wrong, but he had no idea what it was.

Bessemer decided to spend his last penny, if necessary, to



Courtesy Bethlehem Steel Company

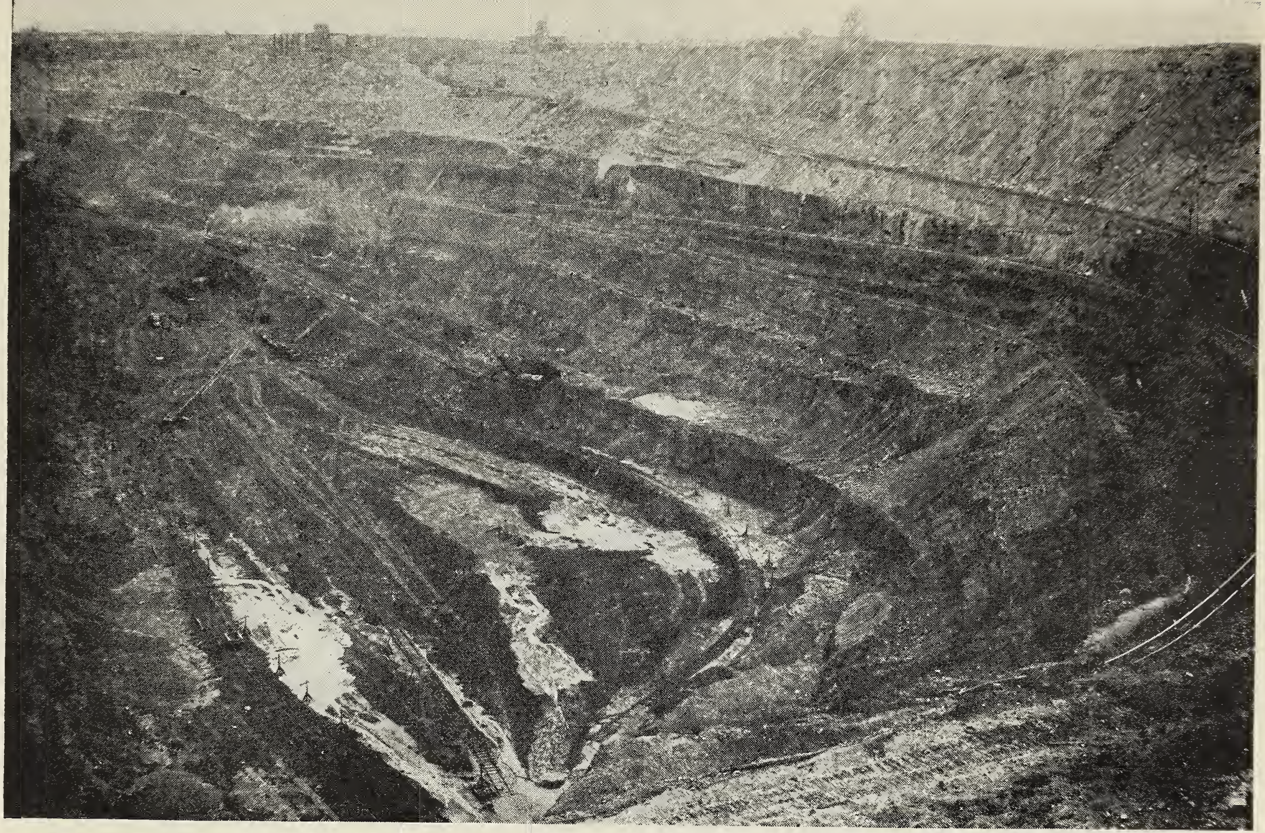
A Bessemer converter in action.

prove the value of his invention. He made one experiment after another, but all ended in failure. He was worn out with hard work and anxiety. His friends tried to get him to give up, but he would not. In his first experiment he had made good steel, and he would make it again.

At last Bessemer discovered the trouble. The pig iron that was being used had phosphorus in it, and Bessemer could not make steel by his process from iron containing phosphorus. He learned that pig iron without phosphorus in it could be obtained from Sweden. He immediately ordered some and melted it in the converter. To his delight it proved to be steel of excellent quality. Shortly after this it was discovered that with a little care pig iron could be produced in England free of phosphorus.

But even now Bessemer's troubles were not over. Wherever he tried to sell licenses to steelmakers they remembered what had happened before. Everyone said, "Oh, this is the thing which made such a blaze two or three years ago and was such a failure," and nobody would buy them. Then Bessemer built a plant at Sheffield and produced steel at fifty dollars a ton as good as that being sold elsewhere for several times the amount. Toolmakers gradually began buying Bessemer's steel. They found it satisfactory and bought more. So Bessemer's steel gradually found its way into tools, engines, machines, and many other useful things.

When Bessemer tried to get a patent on his invention in the United States, he found that William Kelly had also discovered how to turn iron into steel by forcing an air blast through it. Our patent office gave Kelly the credit of being the first inventor of this process and granted him the American



Courtesy Hibbing Chamber of Commerce

A part of the great Mesabi iron formation in Minnesota. Here the iron lies so near the surface that railroad cars can be run right up to it and filled by big steam shovels.

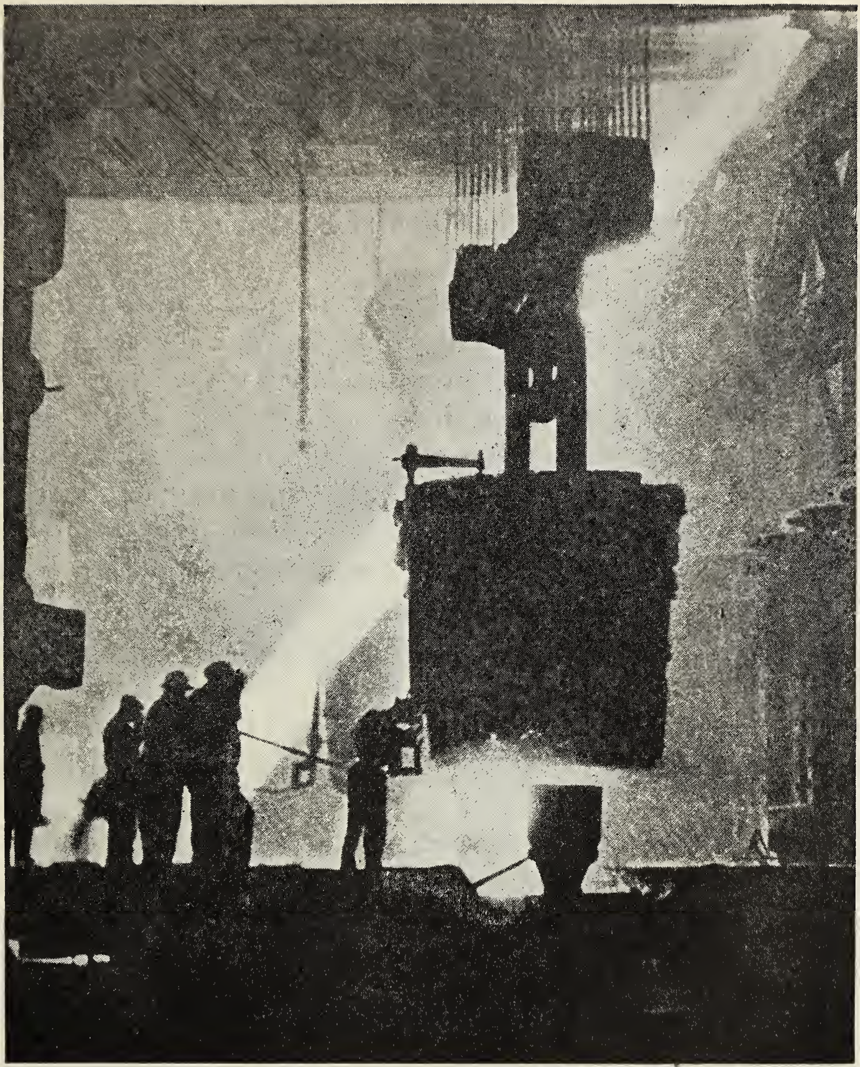
patent. But because Bessemer first brought the process to the attention of the world, this method of making steel is called the Bessemer process. By this method steel could be made cheaply and in great quantities. Thus the modern age of steel began.

Just when the Bessemer method of making cheap steel was being developed, some men exploring the wilderness in Minnesota around Lake Superior learned from the Indians about the "mountains of iron" that lay in that region. The Indians called the region Mesabi. The explorers decided to investigate. An old Indian chief, named Manjikikik, offered to guide them to Mesabi. After several weeks' travel in search of this treasure, the Indian guide suddenly stopped and pointed to a distant hill.

"Iron Mountain," he said. "Indian not go near. White man go."

The Indians regarded this red-iron region with superstitious awe and were afraid to venture too near it. The white men pushed on and came upon a vast storehouse of iron, the Mesabi range, which was part of one of the greatest of the world's iron ranges. It is from this region that we, in America, get most of our iron today.

The iron of the Mesabi range, instead of being buried deep under the earth, as it is in most places, lies just below the surface. In mining the iron, therefore, it is not necessary to dig deep tunnels to reach the ore. Long lines of freight cars are run close up to the gigantic pits. A huge power shovel opens its jaws, digs into the reddish-brown iron ore, and scoops up several tons; then, swinging sideways, it dumps the iron into the waiting freight cars.



Courtesy Iron Age

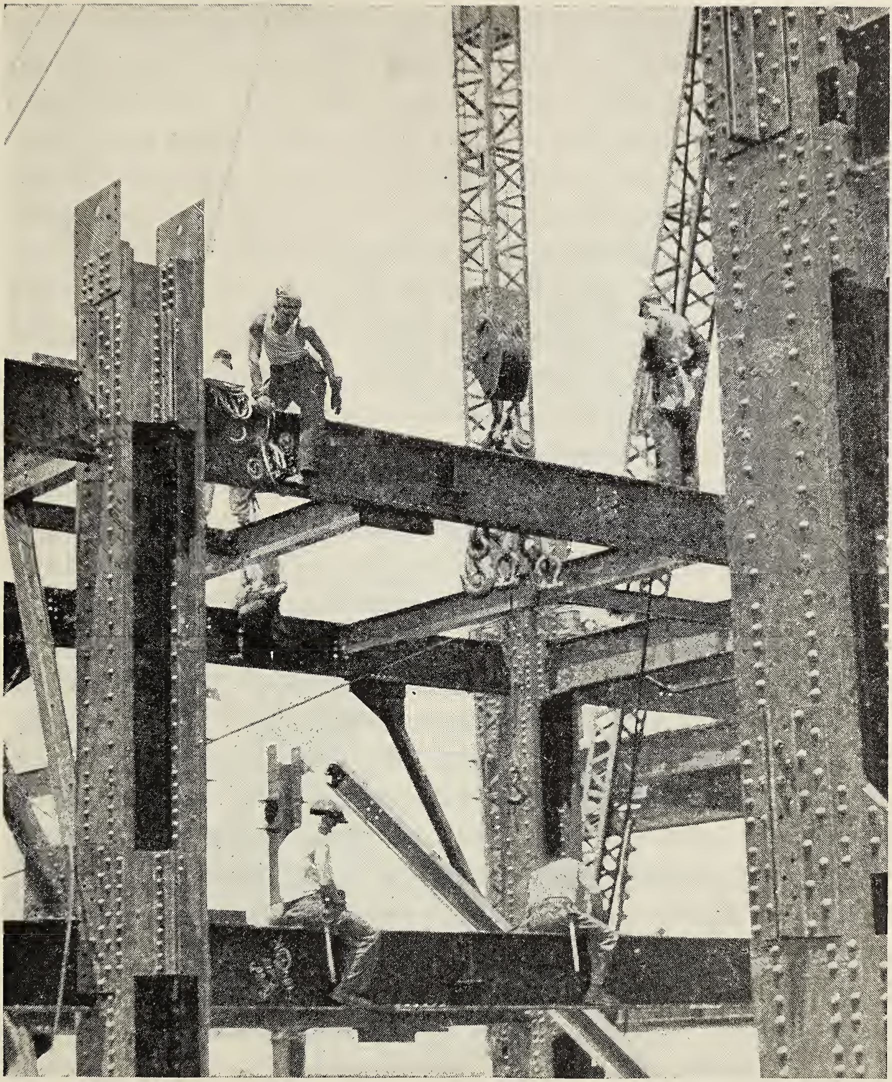
Swung about by overhead cranes, huge ladles pour the molten steel into molds.

After all the freight cars are filled they are hauled to a big dock at Duluth or some other port on Lake Superior. There the tracks run out on top of high trestles built above a long pier. A big steamboat comes alongside the pier, its hatches are opened, and the ore rushes down through long chutes into the ship's hold. By this method thousands of tons of ore can be loaded in a short time.

When its hold is full the mammoth boat steams away on its journey to some port on Lake Michigan or Lake Erie. On the water front are monster iron machines which do the unloading. Iron scoops reach down into the hold of the ship, seize big loads of ore and empty them into freight cars. Soon the train of ore is speeding on its way to Pittsburgh, or Youngstown, or some other steel center.

In the steel plant there is a long row of blast furnaces, which look like tall chimneys. At one side is an elevator for hoisting to the tops ore and coke and limestone, which are fed into their long, fiery throats. The raging coke fire produces terrific heat. The oxygen of the ore unites with the hot coke and gases of the furnace, leaving rivulets of molten iron which trickle down to the bottom of the furnace.

Every little while the furnace is tapped and out comes a blinding stream of liquid iron which flows into giant buckets, called ladles. An engine steams away with the ladles to the converters. A strong blast of air is turned on and rushes with a terrific roar through the metal. The mass of liquid steel seethes and boils. Then the fireworks begin. Flames of brilliant orange, blue, and purple, and showers of sparks shoot out of the mouth of the caldron. In a short time the flames turn to brilliant white.



Courtesy Empire State Building, New York

Steel girders form the framework of our great skyscrapers.

Soon the tempest dies down and quiet reigns once more. The huge caldron is tilted sideways and pours its liquid product into ladles, which swing about and pour the metal into clay molds on little cars. The train of cars moves out, carrying the steel to the rolling mills. An iron arm lifts off the molds, and there stand white-hot blocks of steel, called ingots.

From the ingots steel can be fashioned in any shape desired. Swung about by mighty cranes, they are hammered and punched into various shapes. At the rolling mill a crane seizes an ingot and swings it on to rapidly turning, giant rollers. The steel is rolled back and forth between them. At the end of each rolling the ingot comes out a little longer and thinner, and perhaps it is made into a long rail for a railroad track. In other parts of the mill the steel is rolled into thin sheets, or drawn out into wire.

Our modern industrial civilization rests upon a foundation of steel. Without it men could not build the giant locomotives that speed along their steel ways to all parts of the land, or the mammoth ships that make their way over every sea, safely outriding the fiercest gales. They could not build skyscrapers reaching up to the clouds, unless they were supported by trusty steel frames. They could not build bridges, or tunnels, or any of the other great structures of the modern world, all of which require the strongest material man is able to make.

CHAPTER XI

Making Rubber Useful

ANOTHER material which has become one of the most useful to the modern industrial world is rubber. Rubber has a remarkable quality which nothing else possesses. It quickly comes back into shape again after it has been pressed or stretched. It is also airtight and watertight, and a nonconductor of electricity. For untold ages, rubber trees had grown wild in the jungles of Brazil and other countries, but rubber was not made known to the world for many centuries.

On his second voyage to America Columbus discovered the Indians playing with little black balls, made of the hardened juice of a tree, which, "when they threw them on the ground, did rebound into the air." When he returned to Spain he took back some of the black, bouncing balls given him by some Indian boys, and showed them to King Ferdinand and Queen Isabella. But the king and queen, who had hoped for gold, looked at them with scorn. Little did they think that four hundred years later men would change that strange, gummy substance into more gold than they ever dreamed of. When the Portuguese settled in Brazil they found the Indians there also using the same gummy tree juice. When white people first came to Central America and South America they, too, saw the Indians playing with balls made of rubber.

After this we hear little of rubber for three centuries. About the year 1700 a ball of gum found its way to England, and Dr. Joseph Priestley, a famous English scientist, discovered that it would rub out pencil marks. From that time this strange substance became known as rubber.

More than fifty years later Charles Macintosh, a Scotch manufacturer, found a way of waterproofing cloth by spreading on it a thin coating of rubber. Then came into style the mackintosh, named after its inventor, which was the forerunner of the present-day raincoat. Rubber shoes were also made, which were much in demand for wet weather. These articles of clothing soon ceased to be popular, however, for it was discovered that rubber had two serious faults: in the summertime it became soft and sticky, and in cold weather it grew hard and stiff.

Everybody wanted rubber shoes and waterproof coats for stormy weather, but no one was able to make them so that they would not be affected by the heat and the cold. Unless these faults could be overcome rubber would never come into general use. The manufacturers of rubber goods were in despair. The man who succeeded in making rubber useful was a Connecticut hardware merchant named Charles Goodyear.

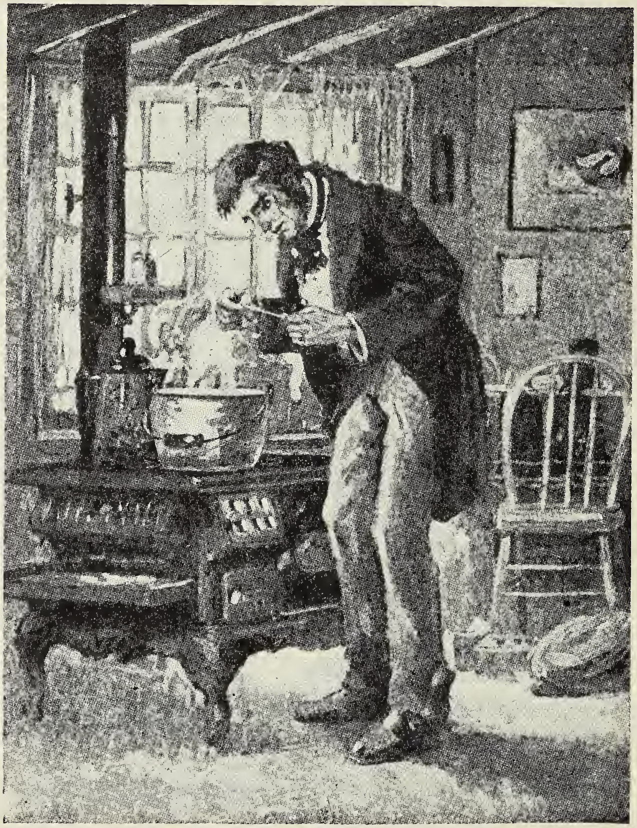
Goodyear felt sure that some way could be found to make rubber firm, yet flexible, regardless of temperature. He thought about it during the day and dreamed about it at night. He began to work in the kitchen of his home. There, day after day, he experimented. He kneaded rubber with his hands and rolled it with his wife's rolling pin. When his wife took her loaves of bread from the oven he would put a batch of rubber in to bake and would watch it all evening and far into the night to see what effect the baking had on it. He would boil rubber in his wife's saucepans, steam it before the spout of the teakettle, roast it in hot ashes, toast it before a slow fire. But no success rewarded all these efforts. Then he tried mixing rubber with various substances, but none of his experiments succeeded.

One day Jerry, an old Irishman whom Goodyear employed to help him, declared that he had discovered the secret. Goodyear had been out and left him at work; while alone, Jerry had plastered his overalls with liquid rubber, to make them waterproof. For a moment Goodyear thought that Jerry might have blundered upon the solution. But, sad to say, shortly after this Jerry sat down near the fire; when he tried to get up he found that his legs were stuck together and that he was firmly glued to his chair. Goodyear had to cut him out of his overalls. Again Goodyear's hopes were dashed to the ground.

During all these years of experimenting Goodyear became very poor. He had a wife and seven children to support and his family was often without food. But he had no thought of giving up his experiments with rubber. He borrowed money whenever he could. When he was unable to repay it, he was thrown into prison for debt. Even there he continued his experiments.

He was ridiculed because he wore rubber clothes, trying to demonstrate to people how rubber might be used. When he was seen on the street dressed in rubber coat, rubber cap, and rubber shoes children called after him, "Rubber! Rubber!" Even his friends tapped their heads as he passed, indicating that he was losing his mind. Someone said of him at this time:

"If you meet a man who has on an India-rubber cap, stock, vest, and shoes, with an India-rubber purse without a cent of money in it, that is Goodyear."



Courtesy Goodyear Tire and Rubber Company

Charles Goodyear discovering how to vulcanize rubber.

So, year after year Goodyear toiled on without success. Then one cold, winter day, in 1839, just as he was about to give up the struggle after all his sacrifices, the solution came to him when he was least expecting it. He was experimenting in the kitchen of his home, as usual, this time trying the effect of combining sulphur with rubber. He was standing near the stove, talking with some friends, when a piece of the rubber and sulphur mixture, which he had in his hands, accidentally fell on the hot stove.

After the rubber had cooled enough to be handled, Goodyear found, to his astonishment, that a magic change had come over it. It was not sticky, as heated rubber had always been before, and it stretched easily, without cracking or breaking. Apparently he had found how to make rubber resist heat. Goodyear was overjoyed.

But would the rubber endure cold without becoming too hard for use? That night, before he went to bed, Goodyear nailed his wonderful piece of rubber outside the door. He was up early the next morning and was delighted to find that the rubber was as soft and flexible as it had been the night before. Here, at last, was the long-sought discovery! Goodyear patented the process and called it vulcanizing, after Vulcan, the Roman god of fire.

Even after his discovery Goodyear had a hard time finding anyone who had faith enough to invest money in it. But at length he succeeded in getting enough capital to build a factory to produce rubber in quantity.

Many people tried to take unfair advantage of Goodyear's discovery, and he often had to defend his patents in court. He spent his last years fighting for his rights and striving to regain his health. Wealth finally began to come to him and he lived to see his rubber used in hundreds of different ways.

Since Goodyear's time many new uses have been found for rubber and today there is scarcely a civilized community anywhere in the world where rubber is not used. Rubber clothing protects us against storm, and rubber footwear guards us against cold and wet. Tennis balls and other kinds of rubber balls provide healthful sport for many people. The telephone and the electric-lighting system make use of rubber. It is utilized in the construction of ocean cables. Radio sets have many important rubber parts. No home would be modern without the many rubber articles in daily use. But greatest of all is the part it plays in the field of transportation, especially for automobile tires.

How and where is the world's rubber produced?

When the bark of a rubber tree is cut, a milky liquid called latex oozes out from the inner side of the bark to heal the wound. The natives of South America, who were first to gather rubber for the market, rose very early in the morning while it was still dark. Barefooted, they started out through the forest jungle. From one rubber tree to another they went, cutting off a narrow, slanting strip of the bark from a quarter of the tree's circumference. Then they inserted little spouts at the lower end of the cuts. They hung cups about the size of teacups under the gashes. From the broken surface of the bark the latex dripped into the cups.

Several hours later the natives again made their rounds and gathered from the cups the milky substance that had collected drop by drop. They went from tree to tree, collecting the latex in large buckets. These they carried to a near-by hut, where they built a fire.

The native dipped a kind of paddle in the rubber sap. Then he held the coated paddle over the smoky fire, turning it

Courtesy Goodyear Tire and Rubber Company

Natives gathering sap in South America.

slowly around and around until the rubber hardened. When the first layer was firm, he dipped it in the sap again. He did this over and over until his bucket was empty and he had a large ball of rubber. When there were enough rubber balls they were loaded on a raft and sent down the river to ships, which carried them to the rubber manufacturers.

The hot, damp jungle of the Amazon valley in Brazil, lying near the Equator, with a rainy season which floods the jungle for half the year, is the ideal home of the rubber trees, which grow wild there in abundance. For years after the time of Goodyear the wild rubber trees of Brazil supplied most of the rubber of the world.

An Englishman, named Wickham, who had spent some years in South America, saw the difficulties of gathering rubber from the jungles. Often the rubber trees grew far apart and the native gatherers had to travel long distances through the dense undergrowth to get their rubber. After that it had to be shipped perhaps two thousand miles down the Amazon before it started on its ocean voyage to the world's markets. Wickham believed that rubber could be cultivated, and saw that if the seeds were planted close together in rows the trees could be easily tended and tapped, and the rubber gathered quickly.

Wickham was commissioned by the English government to send a cargo of rubber seeds to England, in order that his idea might be tried out. The precious seeds were planted in London and grew well. Several cases of seedlings were then shipped to Great Britain's Far Eastern possessions, and in about five years the trees were ready to be tapped. From these few trees grew the rubber plantations of the Far East.

When the automobile was invented the demand for rubber became very great and businessmen saw in rubber an opportunity to make their fortunes; so rubber plantations quickly multiplied. Because the plantation rubber can be grown and marketed more economically than wild rubber, Brazil today supplies only a small part of the world's rubber, while the plantations in the East furnish all the rest.

On the plantations the latex is poured into flat pans, and a small amount of acid is added to make the solid particles of rubber in the latex rise to the surface, where they form a thick sheet. This curdlike substance is taken out and run through rollers which squeeze out all the liquid. Then the rubber is hung in the smokehouse and smoked for about fifteen days. After this the sheets of rubber are ready for their long voyage across the seas.

So important is rubber to the modern world that all industrial nations are interested in lands which have a climate suitable for rubber plantations. England from the first has led in this industry, and today she controls more than three fifths of the world's rubber production. The great rubber-using companies of the United States, however, are now developing rubber plantations in the rubber-growing countries of the world.

CHAPTER XII

Stitch! Stitch! Stitch!

ALTHOUGH machines for spinning and weaving cloth had been invented before 1800, up to the middle of the nineteenth century all garments were still sewed entirely by hand, either by people in their own homes, or by seamstresses or tailors in little shops. For a long time inventors, both in Europe and America, had been trying to make machines that would sew, but no one had succeeded. Then, in 1845, Elias Howe, of Massachusetts, invented a machine that sewed much faster than human fingers could stitch.

When Howe was a young man he worked in Cambridge, Massachusetts, in the shop of a Mr. Davis, who repaired clocks and watches and other things. One day a man who had been trying to invent a knitting machine came to the shop with a model, to see whether Davis could help him with it.

"Why do you bother with a knitting machine?" asked Davis. "Why don't you make a sewing machine?"

"I wish I could," said the man, "but it can't be done."

"Oh, yes, it can," replied Davis. "I could make a sewing machine myself."

"Well," responded the caller, "you do it, and you will have an independent fortune."

Young Howe, who was working at his bench, could not help hearing the conversation of the two men. A fortune for the man who could invent a sewing machine! From that moment the idea of inventing a sewing machine never left Howe's mind.

At night, when he came home from his day's work, Howe always found his wife stitching, stitching. He had only small wages, and she had to work long hours with her needle to clothe their children. Howe would sit in his humble home, watching his young wife's busy fingers, as her needle flew in and out, in and out, through the cloth. If only he could make a machine that would push the needle back and forth through the cloth, women would be saved that endless stitching by hand. He watched and worked, trying to invent a machine that would imitate the motions of his wife's hand in sewing; but every attempt failed.

Howe decided to devote all his time to his invention, so he gave up his position in the machine shop. For years he tried one device after another, but without success. He was so poor that his family were in want. Fortunately an old friend, George Fisher, came to his rescue by lending him some money. Fisher also offered to provide a home and board for his family so that Howe might work out his ideas. For this Howe agreed to give his friend a half-interest in his invention. So the Howe family moved into Fisher's house and a workshop was set up in the garret. Fisher said afterward, "I was the only one of his neighbors and friends who had any confidence in the success of the invention. Howe was looked upon as very visionary and I was thought foolish to assist him."

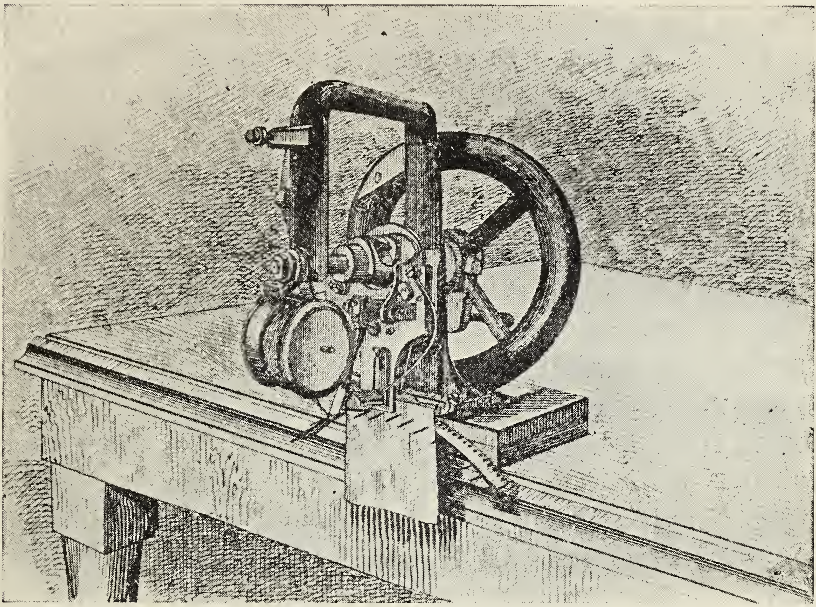
Day and night Howe tinkered away in the garret. His first idea was to make a machine with a needle, sharp at both ends and its eye in the middle, that would work up and down through the cloth, carrying the thread with it. After wasting much precious time he finally saw that a single thread would not do for his machine. He must use two threads: one to go through the eye of the needle, which would pass through the cloth and make a loop in the thread; the other, carried in a shuttle driven back and forth, would go through the loop of the first thread and make a lockstitch.

It is said that the idea of how he could do this came to Howe in a dream. One night, worn out after long hours of work, he threw himself on his bed and fell asleep. He dreamed that he had been captured by a band of savages who took him before their king. The king ordered him to make a machine that would sew, and gave him just twenty-four hours to complete it or else forfeit his head.

In his dream Howe tried and tried again to make a machine and failed, and he saw himself condemned to die. Savage warriors were advancing to take him away to be executed. Howe noticed that they were armed with spears and that the spears had eye-shaped holes in them near their heads. He woke with a start. His problem was solved! What he needed was a needle with an eye near the point. Springing out of bed, he snapped the point off one of his wife's needles and sharpened the head, thus making a needle with an eye near the point. This he fitted into his machine.

The model of the machine was completed in 1845. It was a strange-looking affair. Would it sew? Howe tried it and found to his delight that his new stitch was very strong and on his little machine he sewed all the seams of two suits of clothes, one for himself and one for George Fisher.

Howe's next task was to introduce his machine to the public. He believed that he could convince people of its value if he could show them what it could do. So he carried the machine to a clothing shop in Boston and offered to sew any garments brought to him. Tailors and seamstresses brought trousers, shirts, waists, and skirts, and were amazed to see the seams sewed perfectly and several times as fast as they could have sewn them by hand. For two weeks Howe sat before admiring crowds, daily sewing seams on his machine. Then he challenged five of the fastest seamstresses to a sewing contest.



The first sewing machine, invented by Elias Howe.

"Give me ten seams of five yards each," he said, "and I will finish five of them before five of the swiftest seamstresses can do the same amount."

Ten seams of equal length were prepared for sewing. One was given to each of five expert seamstresses to sew by hand and the other five to Howe. You may be sure the seamstresses sewed as fast as they could. But although they tried their best, Howe finished his five seams more quickly than any of them could finish one and the work done by his machine was declared to be the neatest and strongest.

Howe thought that after this demonstration he would be swamped with orders, but to his surprise none of the tailors or seamstresses would buy his machine. They were afraid it would sew so fast that it would put them out of work.

One of them said, "We are doing well enough as we are. Your machine is costly to buy and to keep in order. There is no good reason why we should bother with it!"

Even after the machine had been known for more than a year, not one had been sold. George Fisher became discouraged. He had boarded the inventor and his family for nearly two years and had advanced him about two thousand dollars. "I lost confidence in the machine's ever paying anything," he said. So Howe and his family went to his father's home to live.

As time passed and there seemed no prospect that the sewing machine would attract attention in America, Howe thought that perhaps there might be a chance for it in England; so he borrowed a little more money and went to London to see what could be done there. He found an English manufacturer who was interested in his machine, and for eight months Howe worked for the man. But his employer was very disagreeable and finally made it so unpleasant for Howe that he had to give up his work.

It was now 1849. Four years had passed since the invention of the sewing machine. Again Howe was without money. He had scarcely enough to eat to keep him alive. He worked his way back to America as a cook on board ship and landed in New York with only sixty cents in his pocket. News came that his wife was very ill in Cambridge, but Howe had not enough money to pay his railroad fare to get to her. Even his hard-won invention seemed about to be lost to him. While he had been in England other people had taken his idea and were making and selling sewing machines in the United States.

One misfortune after another came to the inventor, but he did not lose courage. He found lawyers who were willing to help him and began lawsuits against those who were using the idea to which he had given years of his life. The battle in the courts was long and hard, but Howe finally established his rights to the invention.

The hand sewers organized to prevent the introduction of sewing machines, which they thought would take away their livelihood. There were sewing-machine riots in several places. Opposition, however, has never prevented the use of an invention which provides a more economical method of doing work. So it was with the sewing machine. Gradually people began to appreciate the value of sewing machines, and soon all who could afford them began using them in their homes. Women who had sewed by hand far into the night found how much time they could save with a machine.

At last, after years of poverty and hardship, Howe raised capital to build a factory in which to manufacture the machine. After that his success was remarkable, and fortune smiled on him. We are glad to know that this patient inventor, after all his struggles, had a few years of honor and reward before he died.

Howe's machine sewed only a straight seam; but as time went on, other inventors kept making improvements until the complicated processes of hemming, gathering, buttonholing, pleating—all could be done by machines. Among those who added new parts was Isaac M. Singer.

Singer was a good businessman and he did much to bring the sewing machine to the attention of the public through advertising. "A sewing machine in every home," was his slogan. Sewing-machine shows were held in many towns and cities. Crowds of women came to see the new marvel and carried home samples of sewing as souvenirs. There were sewing contests with prizes for the speediest sewers. Singer also worked out a plan of installment payments, which made it possible for even poor people to buy machines by paying for them a little at a time.

The sewing machine was first used only in homes, but later it was introduced into factories and operated by power. This made possible cheap, ready-made clothing. No longer did the mother of a family have to sit for hours sewing clothes for herself and her family. Factories, using hundreds of power machines and employing thousands of men and women to tend them, turned out many garments in a day.

Today sewing machines are used not only for making clothes, but also for stitching shoes, pocketbooks, traveling bags, and many other things.

CHAPTER XIII

Dots and Dashes

IN AN earlier chapter we saw how, little by little, men discovered strange facts about the mysterious force of electricity. Up to the time of Faraday electricity was of interest only to scientists. No one dreamed that it could be put to practical use in the world. But in the latter part of the nineteenth century, while men were learning to use electricity as a source of power, inventors applied the knowledge accumulated by the scientists of earlier days to give the world marvelous new methods of communication. These were of great importance in building up the modern industrial world.

Early in the history of the world, governments began to feel the need of keeping in touch with all parts of their countries. The necessity for sending news quickly over great distances was sometimes urgent, especially in times of war or other danger. The ancient nations worked out various means of doing this.

The ancient Chinese, the Egyptians, the Persians, the Greeks, and the Romans, all sent messages by swift runners. Sometimes the messengers were mounted on horses. After man learned to write, written messages were carried and postal systems were developed. At intervals along the Persian roads were posts at which were kept horses and couriers, in order that mail might be relayed as quickly as possible. Rome had a wonderful system of post roads that connected her with all parts of her far-flung empire.

Neither runners nor horsemen were fast enough for urgent messages. Both sound and light lend themselves to the sending of messages, which can move through the air faster than man or horse can travel; and many ingenious methods of signaling by light and sound were worked out.

The many devices for carrying messages show how eager man has always been to overcome the barriers of time and space. Methods like these we have described did fairly well during earlier centuries; but the new industrial life, developing so rapidly in the nineteenth century, made some quicker means of communication essential. It was natural, therefore, that, after Volta had shown that an electric current could be sent any distance over a wire and Oersted had shown that an electric current would cause a magnetic needle to turn from side to side, men with inventive minds should try to apply the forces of magnetism and electricity to the task of speeding up communication.

The first of these inventions was the electric telegraph. Several men in Europe had been trying to invent a telegraph, but an American, Samuel Morse, was the first inventor to make one that was really successful.

After graduating from college Morse decided to be an artist, and in time came to be a successful portrait painter. But he was not satisfied with his success. He wanted to paint great historical pictures. To prepare himself to paint the pictures of which he dreamed, he went abroad to visit art galleries and study the paintings of the great masters. In

1832, after three years in Europe, he returned to America on the packet ship *Sully,* and on the voyage home he reached a turning point in his career.

In those days the trip across the ocean was a long one and the passengers on a ship had a great deal of time to visit with one another. There was a pleasant company of people on board the *Sully,* and there were interesting talks on all sorts of subjects. One night at the dinner table a Dr. Jackson described some wonderful electrical experiments which he had seen performed in Paris.

"Does the length of the wire affect the speed of the electric current passing through it?" someone inquired.

"Oh, no," replied Dr. Jackson. "It passes instantly over any length of wire."

Morse was interested, and suddenly the idea came to him that messages might be sent long distances over wires. "If the presence of electricity can be made visible in any part of the circuit, I see no reason why intelligence may not be transmitted instantaneously by electricity," he said.

The conversation continued, but Morse no longer heard it. The idea of sending messages by electricity completely filled his mind. For the rest of the trip he could think of nothing else. As he left the ship he said to the captain, "Well, captain, should you hear of the telegraph one of these days as the wonder of the world, remember that the discovery was made on board the good ship *Sully.*"

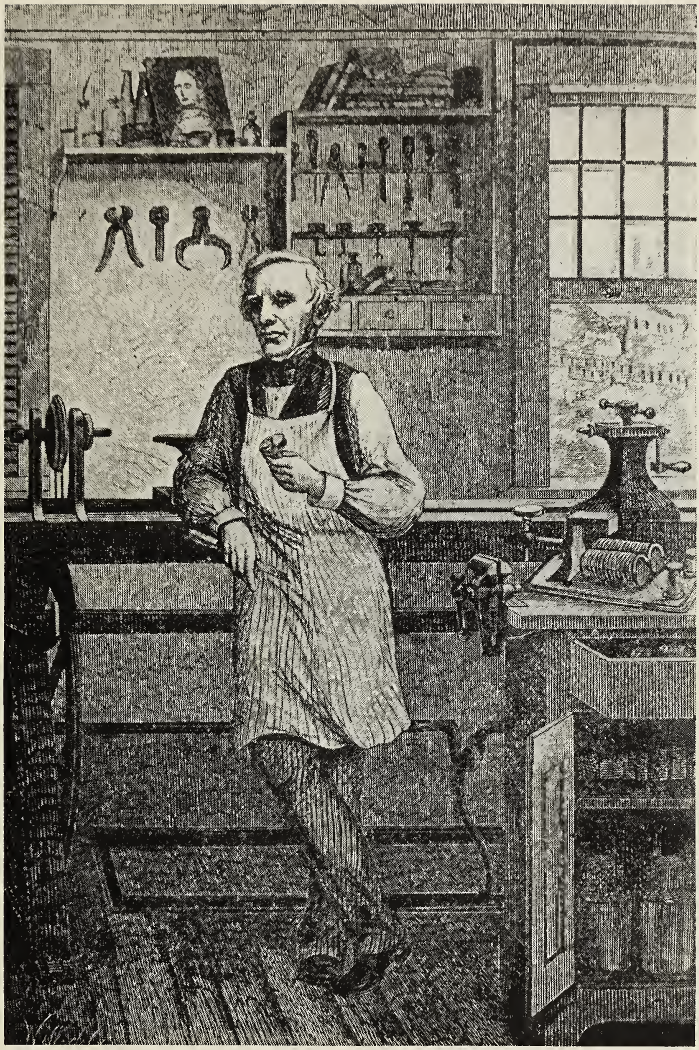
After his return to New York art no longer occupied first place in Morse's mind. The invention of a telegraph was his constant thought, and he wanted to spend all his time working on it. While he was busy with it he was able to earn so little money that he became very poor. The struggling inventor lived all alone in a little room in the top story of a building in New York. "So straitened were my circumstances," he afterward wrote, "that, in order to save time to carry out my invention and to economize my scanty means, I lodged and ate in my studio, procuring my food in small quantities from some grocery and preparing my food myself. To conceal from my friends the stinted manner in which I lived, I was in the habit of bringing my food to my room in the evenings, and this was my mode of life for many years."

After several years Morse succeeded in making a crude model of an instrument that would work. As he could not afford to buy materials for it, he had contrived it out of an old picture frame, the wheels of an old clock, scraps of wood and metal, and bits of wire.

He also invented a code for sending messages. Each letter of the alphabet was represented by different combinations of dots and dashes, made by breaking the current of electricity. When the operator at one end of the wire pressed down a key there was a sharp click at the other end; this made a dot on a piece of paper. If he pressed the key and held it down for a moment, it made a dash.

The alphabet looked like this:

A.–
B–...
C.. .
D–..
E.
F.–.
G––.
H....
I..
J–.–.
K–.–
L––
M––
N–.
O. .
P.....
Q..–.
R. ..
S...
T–
U..–
V...–
W.––
X.–..
Y.. ..
Z... .



Samuel Morse in his workroom.

All who saw the telegraph were convinced that it was a very valuable invention. Though scientists and friends flocked to see the new marvel of electricity, they could not help Morse financially. But in 1837 assistance came to Morse quite unexpectedly. One day a young man by the name of Alfred Vail visited Morse and was greatly impressed by what he saw. He watched the telegraph in silence for some time and then said, "Your wire here is not very long. What reason have you to believe that your telegraph will act successfully at great distances?"

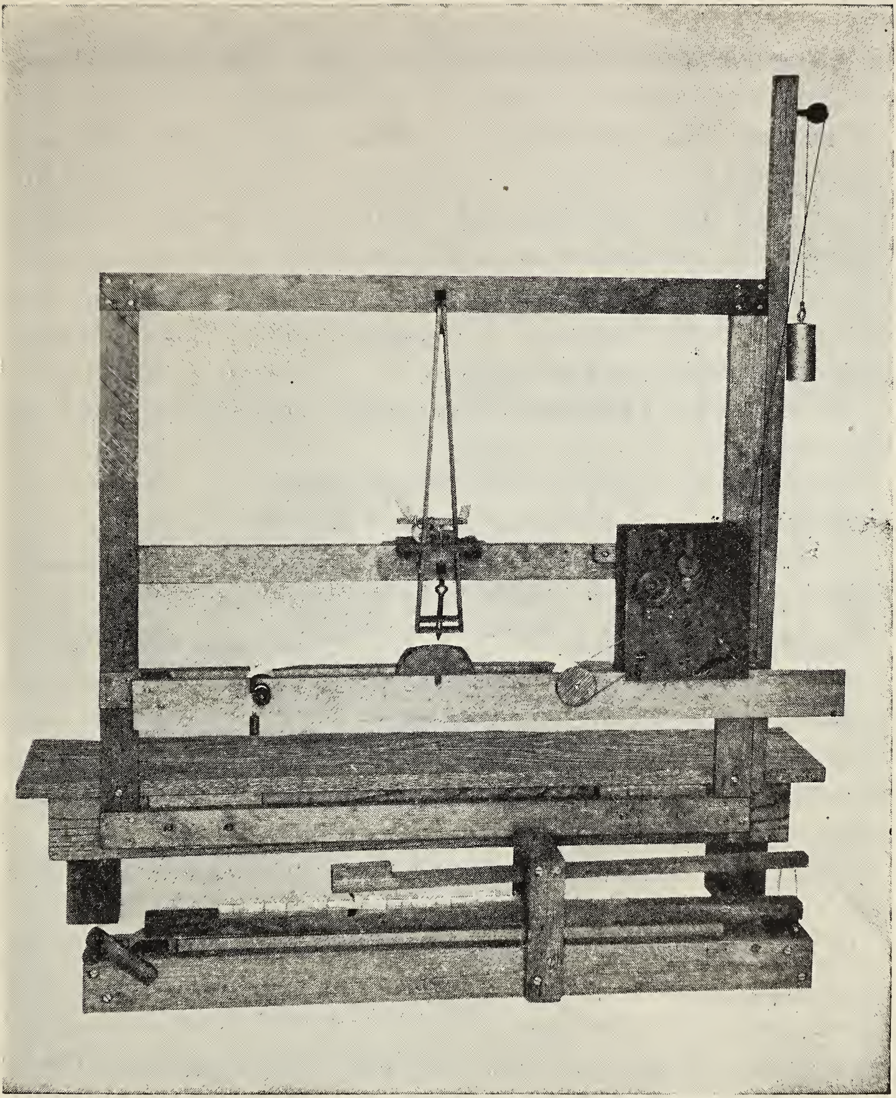
"If I can succeed in working a magnet ten miles away, I can go around the globe," answered the confident inventor. "I have contrived a way of renewing the current with a relay. It would not be worth while to have these relays closer than ten miles from each other. But if I can get a force strong enough to lift a hair at a distance of ten miles, I can send a current around the earth."

Young Vail asked Morse why he did not push his experiment more rapidly and learned that the delay was caused by lack of money. Two thousand dollars were needed to improve the instrument and secure patents.

"If I can furnish financial backing," said the young man, "will you give me a fair share in the enterprise?"

An agreement was reached, the money was obtained, and with Vail's help Morse was able to take the necessary steps.

As it would be very expensive to build a telegraph line over any considerable distance so that his invention might have a real test, in 1838 Morse appealed to Congress to give him enough money to build an experimental line from Washington to Baltimore. But the members of Congress laughed at the



Courtesy Western Union Telegraph Company

The first telegraph, made from an old picture frame, some old clock wheels, and bits of metal and wood.

idea of a telegraph, saying that they might as well give Morse the money to build a railroad to the moon.

The next few years were the darkest in Morse's life and many a time he was tempted to give up. He had neglected his art so long that it was hard for him to get pupils to teach. Often he did not know where his next meal was coming from. On one occasion a pupil did not pay his tuition on time and Morse inquired about it. The pupil replied that he would have the money the next week.

"Next week!" repeated Morse sadly. "I shall be dead by that time."

"Dead, sir?" cried the astonished student.

"Yes, dead by starvation," replied Morse.

Fortunately the student was able to procure some money and Morse had his first meal in twenty-four hours.

In the winter of 1843 Morse went once more to Washington to seek the aid of Congress. Day after day he attended the sessions, vainly hoping for mention of his appropriation. He displayed the telegraph and it was well thought of. Many members of Congress, however, were afraid that it would never be a commercial success.

"Your idea is good, Mr. Morse," said one member, "but it won't pay."

In the evening of the last day of the session Morse sat waiting in the gallery of the Senate. His bill had passed the House but still had to pass the Senate. All business must be finished before twelve o'clock that night. At ten o'clock there were still many bills to be considered. There was no chance, it seemed, that his bill would come up before adjournment.

Morse's friends urged him not to wait longer. One Senator said, "There is no use your staying here. The Senate is not in sympathy with your project. I advise you to give it up, return home, and think no more about it."

And so, through the dark streets of Washington, Morse made his way wearily to his boardinghouse. He had given years of his life to perfecting his invention, and he had succeeded; but his work was treated with indifference. It seemed as if his last hope had gone.

You can imagine Morse's surprise and joy, early the next morning, when Miss Annie Ellsworth, the daughter of a friend, appeared and congratulated him on the passage of his bill. At the very last minute the bill had been passed and an appropriation of thirty thousand dollars had been made to construct an experimental line.

Thirty thousand dollars! Now the telegraph line could be built! It seemed too wonderful to be believed. For a moment Morse was so overcome by the news that he was unable to speak. Then he said to Miss Ellsworth, "You were the first to bring me the good news, and you shall send the first message over the telegraph when it is done."

"I shall hold you to your promise," replied the young girl.

Speedily the work of constructing the telegraph line between Washington and Baltimore went forward. Poles were set up and wires strung, and at last, on May 24, 1844, the forty-mile line was ready for the official trial. Samuel Morse sat in an office in Washington. It had been announced that the first message was to be sent, and crowds gathered. Morse sent for Miss Ellsworth and asked her to give him the words for the message. The words she chose were, "What God hath wrought," from the Bible.

Click! Click! Click! went the electric tapping, and the world's first telegraph message flashed along the wire with incredible speed to Vail, who was in Baltimore. A great crowd of people had gathered in the room in Baltimore, where a little instrument was making queer little dots and dashes on a strip of paper. Slowly, steadily, the marks appeared, dot by dot, dash by dash, until Vail had received the whole message. Then he sent the same words back to Washington to prove that he had received the message. It had flashed from Washington to Baltimore and back, a distance of eighty miles, in an instant.

So was taken a wonderful step in the history of communication. No longer did people have to send their messages by the slow methods of earlier days; by electricity, messages could be flashed back and forth with the speed of lightning.

But there was still much work to be done. As was the case with many other inventions, one of the real problems was getting the public to understand the value of the telegraph. On April 1, 1845, the line was opened for public use. The receipts for the first four days were one cent. A man who had nothing with him but a twenty-dollar bill and one cent wanted to see how the telegraph worked. He was told that he could see it work if he sent a message. He asked for a message costing a cent. In the code, "4" stood for the question, "What time is it?" The operator sent the signal "4" to Baltimore. Baltimore answered "1," which meant "one o'clock." The man paid his cent and departed.

In a short time, however, came an event which brought the telegraph to the notice of the whole country. The national convention of the Democratic Party was being held in Baltimore and a Senator Wright was nominated for Vice President. Rushing to his telegraph instrument, Vail sent the message to Morse in Washington. Morse immediately went to the Senator, who was in Washington, and told him of his nomination. The Senator was amazed.

"I don't believe it's so," said the Senator. "But if it is, you tell them I won't run."

Morse promptly telegraphed the message to Vail and a few minutes later Vail handed Senator Wright's refusal to the members of the convention in Baltimore. When the message was read in the convention, it caused a sensation. Most of these present refused to believe it, but the members decided to send a messenger to Washington to find out whether it was true. The next morning the messenger returned, saying that Senator Wright would not run and that he had said so the day before. Newspapers all over the country printed the story.

Morse offered to sell the telegraph to the government for one hundred thousand dollars, but the government, fearing that the income would never equal the expense of keeping the lines in operation, refused to buy it. The next step was to organize a company. In 1851 the Western Union Telegraph Company was formed.

This company soon proved that the telegraph could be operated at a profit, for in a short time businessmen were ordering materials and goods, railroad companies were sending information about trains, newspapers were getting their news, and people were sending important messages by telegraph.

Before he died Morse had the satisfaction of knowing that his telegraph was being used in every civilized country of the world.

CHAPTER XIV

Telegraphing Under the Sea

After it was proved that messages could be sent on land by the telegraph, people began to wonder whether it was possible to lay a cable by which to telegraph across the Atlantic Ocean, for it took a long time for messages to cross between America and Europe.

Short cables had been laid through the shallow waters between England and France, but was it possible to lay a cable two thousand miles long across the ocean? Would not a cable drawn out to such a length break to pieces by its own weight? Could ships carry such a cable? If the cable could be laid, could an electric current be sent through it? And think of the cost of making such a cable and laying it at the bottom of the sea! Who would invest money in such an enterprise? All these questions made nearly everyone feel that the laying of a cable under the Atlantic Ocean was an almost hopeless task.

Cyrus W. Field, a wealthy young merchant of New York, became interested in the idea. But before undertaking the task he decided to consult scientific authorities to find out whether it was possible. He appealed to Morse, who replied, "Yes, it can be done." He also consulted Faraday, and when Field asked the grand old man of electricity how long it would take for the current to pass from shore to shore, Faraday answered, "Possibly one second." These opinions convinced Field that the scheme was practicable.

The first step was to find out what the bottom of the ocean was like, for no one knew. Was it level, or did it consist of mountains and valleys? In 1856 Field prevailed upon the government to have a ship sound the ocean along the route where the cable was to be laid. This was done and the ocean bed was found to be fairly level and not too far below the surface of the water for the laying of a cable. It would form a safe bed for the cable to rest on. Field then set out for England to see how the possibility of a cable would appeal to people in the British Isles. In England he was well received and the government promised to send a ship to search the ocean depths off Ireland, to find out how deep the cable would have to be laid.

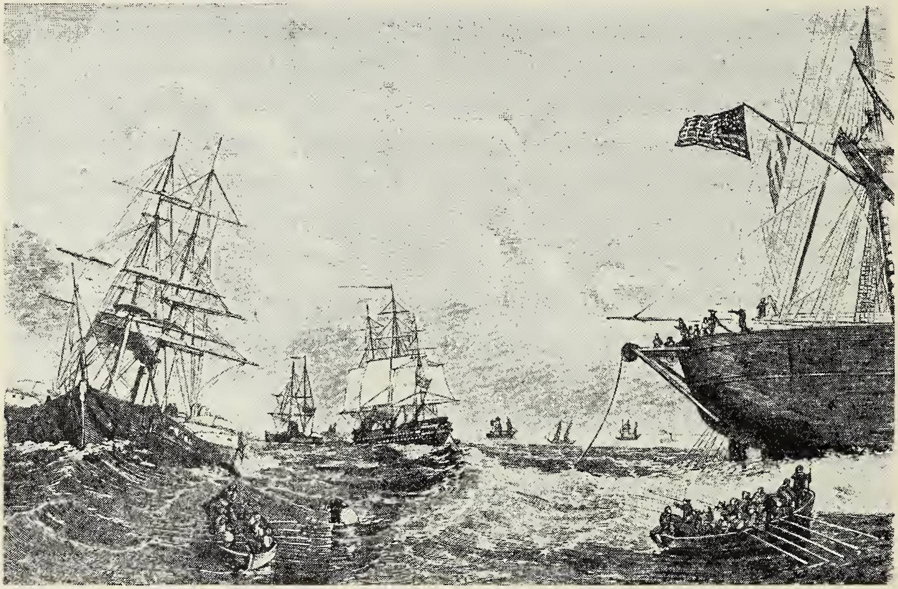
In 1856 Field organized the Atlantic Telegraph Company, investing in it nearly all his money. Could he find anyone to join him? He went about from city to city seeking funds. At last, the necessary sum was secured.

Someone said to Field at this time, "Suppose you do not succeed, suppose you make the attempt and fail, and your cable is lost at the bottom of the ocean. What will you do?"

"Charge it to profit and loss, and lay another," Field replied quickly.

Field set to work at once. The first task was to make a waterproof cover for the copper wires used to conduct the electricity—one which would form a light and flexible, but strong cable. It was found that gutta-percha, a substance somewhat like rubber, was well suited to this purpose. A number of wires were twisted together, each wire covered with gutta-percha and protected by tarred hemp. When the cable was finished, the work of laying it began.

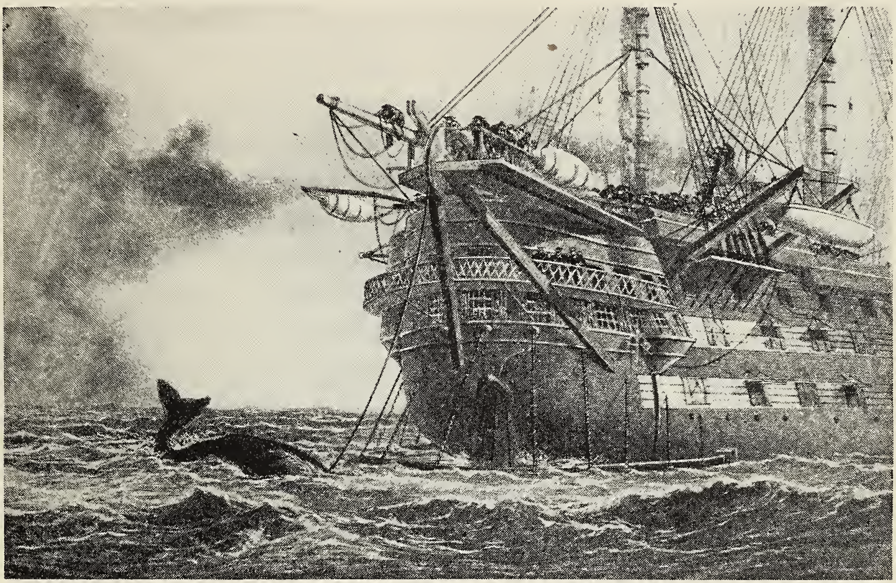
One day, early in August, 1857, the *Agamemnon* and the *Niagara,* which had been furnished by the governments of England and the United States, set out from the coast of Ireland, accompanied by an escort of smaller vessels. The *Niagara* was to lay the first half of the cable from Ireland to the middle of the Atlantic; there the end was to be joined to the other half on board the *Agamemnon,* which would lay the cable to the coast of Newfoundland.



The *Agamemnon* and the *Niagara* laying the cable in 1858.

For six days all went well and nearly four hundred feet of cable was laid. Then a wave rose under the stern of the *Niagara,* causing too great a strain on the cable; it broke and disappeared into the sea.

So ended the first attempt to lay the cable. Half a million dollars had been lost. Field and his associates must wait another year. But Field was not discouraged. Shortly after this he wrote to his family: "The successful laying down of the Atlantic Telegraph cable is put off for a short time; but my confidence was never so strong as at the present time, and I feel sure, that with God's blessing, we shall connect Europe and America with the electric cord."



An exciting moment for the cable layers when a whale crossed the path of the cable and threatened to break it.

The next spring Field was ready to try once more. Again the *Agamemnon* and the *Niagara* put out to sea. This time a different plan was to be tried. The two ships were to go to the middle of the ocean; there the cable was to be spliced and the vessels were to sail in opposite directions until one reached Ireland and the other Newfoundland. With their great coils of cable on board they steamed away toward the middle of the Atlantic. But they had not gone far before they ran into a terrible gale. The *Niagara,* the larger ship, weathered the storm without mishap, but the *Agamemnon* was almost wrecked. For seven days the tempest raged, but, at length, the angry sea calmed down. The ships approached each other and the cable was spliced. The ships parted but had not gone far from each other before the cable caught in the paying-out machinery of the *Niagara* and was broken off. Both ships turned about, the cable was spliced again, and a fresh start was made. All went well, the paying machines worked smoothly, and the cable ran off easily into the sea. When each ship had paid out about fifty miles, suddenly the current ceased. The cable had parted.

Once more the ships came together, the cable was joined, and a third start was made. All went well. Messages were passing from ship to ship. On board the *Niagara* scarcely a word was spoken. Nothing was heard but the strange rattling of the machine as the cable ran out. A hundred miles were laid safely—a hundred and fifty—two hundred. At last the great undertaking was to be crowned with success! Then came the fatal announcement that the current had ceased to flow. The cable had broken about twenty feet from the stern of the *Agamemnon*. This ended all hope for that expedition, so the cable layers returned to Ireland.

After these failures most people thought it was time to stop. To make another attempt to lay a cable was folly. But Field was a persistent man. He thought that he could do no worse than fail again and there was always the chance that he might succeed. He would try a third time. He raised more money and in July the two vessels started out once more. But few people expected success.

The ships reached the middle of the Atlantic, the cable was spliced, and the vessels parted, one sailing eastward, the other westward. Then a strange thing happened, which caused great excitement on board the *Agamemnon*. A large whale was seen approaching the ship at great speed, rolling and tossing the sea into foam all around. It was headed directly for the place where the cable was going down into the sea. Would it break the cable? With bated breath the crew watched it, and great was their relief when the ponderous mass was seen just grazing the cable without doing any harm.

On August 5, 1858, the news was suddenly flashed over the country that the *Niagara* had reached Newfoundland and the *Agamemnon* had reached Ireland. Victory at last! People everywhere went wild with excitement. Flags went up, cannons fired salutes, and church bells rang out joyously. Banquets, jubilees, and fetes were held. The children, let out of school, shouted, "The cable is laid! The cable is laid!"

In New York there was a torchlight procession in honor of Field and his associates. One of the transparencies in the parade said:

LIGHTNING
CAUGHT AND TAMED BY
FRANKLIN
TAUGHT TO READ AND WRITE AND GO ON ERRANDS BY
MORSE
STARTED ON FOREIGN TRADE BY
FIELD COOPER & CO.
WITH
JOHNNY BULL AND BROTHER JONATHAN
AS
SPECIAL PARTNERS

On August 16 the cable was officially opened. The first message came from the directors in England to those in America: "Europe and America are united by telegraph. Glory to God in the highest, and on earth, peace, good will to men." The next day came congratulations from the English Queen "upon the successful completion of this great international work, which will prove an additional link between the nations, whose friendship is founded upon their common interest and reciprocal esteem." The President of the United States replied. Enthusiasm knew no bounds. A new bond was established between the Old World and the New, people said. Many messages were sent over the cable.

But, alas! joy at the success of the cable was short-lived. In less than three weeks something happened to it somewhere on the bed of the ocean. The messages became fainter and fainter. By October no more messages could be sent from continent to continent. Once again failure had overtaken the promoters. Think of the disappointment of Field and the other men who had put their money into the enterprise! Years of effort, millions of dollars spent, one month of messages, and only a useless collection of wires under the ocean! Many people thought that no messages had ever crossed the ocean. They believed that they had been deceived and that the whole thing was a fraud.

Courtesy Western Union Telegraph Company

The successful landing of the cable in Newfoundland in 1866. (From an old lithograph)

By this time Field was financially ruined. Then came the

Civil War, which occupied the thoughts of everybody in the country and no one had time to think about the cable. So seven years passed. Did Field give up? He did not! His faith in the cable kept him going. When things were blackest he wrote: "I never had more confidence in the ultimate success of the Atlantic Telegraph Company than I have today."

In January, 1864, Field was once more on his way to London to try again. New capital was raised, a new company formed, and a new cable made, much stronger than the earlier cables. This time the *Great Eastern,* the largest vessel in the world, was used to lay the cable.

On July 13, 1865, the big ship started from Ireland with her heavy burden and moved steadily ahead on her westward course. For twelve hundred miles she rode the sea, trailing out the cable behind her. Two-thirds of the cable had been laid. Two days more and shallow waters would be reached. Field's hopes rose high. Success seemed near. Then, without a moment's warning, the cable broke and slipped into the sea. Through the ship ran a cry of grief and dismay. Some of the crew turned aside their heads and wept.

For nine days Field and his men hung over the spot where the cable had disappeared, trying to recover it with grappling irons. Day after day the iron fingers raked the bottom of the deep. Three times the cable was caught, but each time it fell back into the ocean. It was no use; the cable was gone. The *Great Eastern* swung about and went back across the waters that had been the scene of so many failures. Field merely said, "We have learned a great deal and next summer we shall lay the cable without doubt."

Field had been working for twelve years trying to lay a cable, and he had not succeeded. A hundred times he had thought he must give up but always came the feeling that he must see the undertaking through. In July, 1866, the *Great Eastern* once more set forth on her stately way across the Atlantic. This time luck, which had been so long against Field, turned toward him. For fourteen days the *Great Eastern* bore steadily westward without mishap. On July 27 she entered the little harbor of Heart's Content, in Newfoundland, and all the ship's crew joined in lifting the heavy cable ashore. It was tested and every signal was answered from Ireland clearly and distinctly.

The great work was at last accomplished. Telegraphic communication was established between America and Europe.

July 27, 1866, was indeed a great day in the life of Cyrus W. Field. For years he had thought of little but the submarine cable. Failure after failure had not discouraged him. Now success had come and he felt rewarded for all his labor and his sacrifices. "I went to my cabin," he tells us. "I locked the door; I could no longer restrain my tears—crying like a child and full of gratitude to God."

Public opinion turned in a great tide toward Field, and honors were heaped upon him. At a banquet given for him in New York he said: "It has been a long struggle; nearly thirteen years of anxious watching and ceaseless toil. Often my heart was ready to sink. Many times on the deck of the ship, on dark, stormy nights, I have accused myself of madness and folly, and yet hope has led me on and I have prayed that I might not taste death till this work was accomplished. That prayer is answered."

Thus was written a wonderful chapter in the story of communication. In a few years lines were laid across the Atlantic in other places, and later, across the Pacific. Today all the ocean beds are crisscrossed by many cables. These magic wires tie the different continents together just as the telegraph ties together places on land.

CHAPTER XV

When Wires First Talked

NO SOONER were the telegraph and the cable successful than inventors began trying to make a machine that would convey the sound of the human voice over long distances. In 1876 Alexander Graham Bell succeeded in doing this.

Bell was a teacher of the deaf in Boston. In working with his deaf pupils he learned much about how sounds affect the delicate eardrum. Could he make a disk of iron that would catch sounds and send them electrically to another disk, which would give them out again? This was the question that Bell asked himself. "If I can make a deaf mute talk, I can make iron talk," he decided, and he set to work to find a way.

One of Bell's pupils was Georgie Sanders, a little deaf boy. Young Bell made his home with the Sanders family and was given permission to use the attic as his workshop. For several years that attic was his favorite retreat. There he experimented, trying by means of tuning forks and electric batteries to invent an instrument that would convey the sound of the voice.

"Often in the middle of the night Bell would wake me up," said Georgie's father. "His black eyes would be blazing with excitement. Leaving me to go up to the attic, he would rush wildly to the barn and begin to send me signals along his experimental line. If I noticed any improvement in his machine, he would be delighted. He would leap and whirl around in one of his war dances, and then go contentedly to bed. But if the experiment proved disappointing, he would settle down doggedly at his workbench and try some different plan."

As Bell had little knowledge of electricity he applied to Charles Williams, who conducted an electrical instrument shop in Boston, for help. Williams assigned to him a young mechanic, Thomas Watson, and Bell moved his workshop to an attic over Williams' store.

One hot day, in June, 1875, the two young men were hard at work, as usual, in the loft over the shop. For three years Bell had been toiling over the telephone with the help of his able young assistant. Bell was in one room and Watson in a room near by. A wire was stretched from one room to the other, connecting their instruments. Watson had charge of the transmitter and Bell was listening intently, with the receiver pressed close to his ear. One of the transmitter springs stopped vibrating and Watson kept snapping a reed on his machine, trying to start it again.

Suddenly Watson heard a shout from Bell, who came rushing into the room.

"What did you do then? Don't change anything. Let me see."

When Watson had snapped the reed, a faint, almost inaudible sound had passed over the wire and Bell's keen ear had heard it. Bell knew that, at last, he had found the secret of the telephone. The young inventor went to work again with renewed enthusiasm. "We did not do anything all that day but pluck reeds," Bell said later.

It was a long time, however, before words could be heard over the wire. For many months the instrument could make only queer noises. But Bell and Watson kept on improving it day by day.

On March 10, 1876, the time had come for a real test of the telephone. The attic rooms were too close together for the experiment. Watson strung a wire down two flights of stairs. Bell was at his instrument in the attic, and Watson was down below. Watson talked into his end of the telephone, but even when he shouted at the top of his lungs, not a sound could Bell hear. Then Bell began to talk to Watson. He had an unusually clear voice, which had been well trained. "I spoke, and shouted, and sang into the instrument," said Bell afterward.

Soon Watson came clattering up the stairs in a state of great excitement, shouting breathlessly, "I could hear you. I could almost make out what you said!"

For the first time in the history of the world one person had been able to talk to another at a distance by means of a wire. You can imagine Bell's joy.

It was by accident, a short time after this, that the first words spoken over the telephone were clearly understood. During one of his endless experiments Bell had been using sulphuric acid and had spilt some of it on his clothes. Suddenly Watson, who was in the next room with his ear to the receiver, was astonished to hear Bell's voice, saying quite clearly, "Mr. Watson, please come here, I want you." The tone of Bell's voice indicated that he needed help and Watson dashed into Bell's room to find that he had spilled the strong acid all over himself. In his delight at realizing the success of the telephone

Bell almost forgot the rapidly spreading acid stains on his suit.

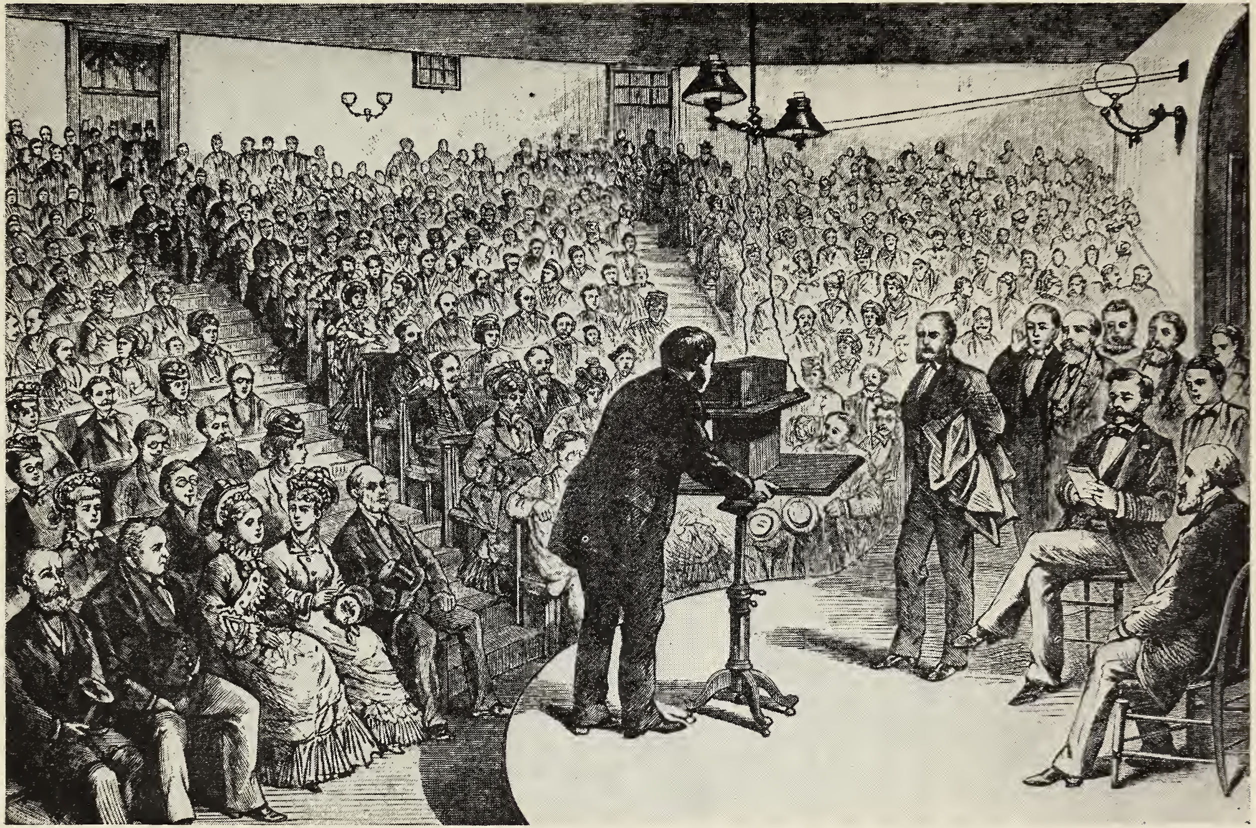
Just at that time there was being held in Philadelphia a fair called the Centennial Exposition. This offered Bell an opportunity to display the new invention. Through the influence of a friend, he was allowed to place a small table in one of the fair buildings, in an obscure corner between a stairway and a wall. There he sat, day after day, for a whole month, exhibiting the telephone; but no one paid much attention to it.

On June 25, 1876, came the big day of the exposition, when the judges were to look at the various exhibits. Seated at his little table in the out-of-the-way corner, Bell patiently waited to show them the telephone. At last they came. It was seven o'clock in the evening. It had been a hot day. The judges were tired after their long day of inspection and they passed by the telephone, scarcely noticing it. Bell's heart sank.

Then a most unexpected thing happened. Dom Pedro, the young Emperor of Brazil, happened to be visiting the exposition and was the guest of honor that day. With a group of courtiers he entered the room just as the judges were passing Bell's table. He had visited Bell's classes for the deaf on an earlier trip to this country and had been much interested in the work.

Catching sight of the young inventor, Dom Pedro advanced toward him with hands outstretched and greeted him warmly, "How do you do, Professor Bell? I am delighted to see you again."

The Emperor was all interest in the telephone and nothing would do but that Bell should explain this new idea of his. Bell asked the Emperor to take a seat at the table on which



Alexander Graham Bell demonstrating his newly invented telephone in 1877 at Salem, Massachusetts. Some of the important men of the town talked through the telephone to friends in Boston, to prove that it really worked. (From *Frank Leslie's Illustrated Newspaper*, 1877) rested the receiver, and told him to hold his ear near the queer-looking little instrument. The inventor went into another room and spoke slowly and very distinctly into the transmitter. Dom Pedro, of course, had no idea what would happen, nor had anyone else in the room. There was a moment's pause; then, suddenly, the royal visitor, looking at the little instrument, exclaimed in awed tones, "It talks!"

The judges, pausing, heard what Dom Pedro said, and turned back to see the telephone. They forgot the heat, their hunger and fatigue. One after another of the notable company listened to the voice coming from the box, and all expressed their amazement at the invention. The little instrument, which had been neglected for so long, was acclaimed the wonder of wonders and was brought out of its obscure corner and given a place of honor at the exposition.

Much work remained to be done on the telephone; so Bell returned to Boston and hired two rooms for Watson and himself at an inexpensive boardinghouse. Up to that time all the communicating had been done indoors. But by October, 1876, Bell was ready to try his invention out of doors. A telephone line was run from Boston to Cambridge, a distance of two miles. Then came the test of the new telephone. One night Watson went to Cambridge, while Bell remained in Boston. Watson put his ear to the telephone and in intense expectation waited for the sound of Bell's voice. Not a sound could he hear. Watson shouted into his receiver. Bell listened; but even when Watson shouted his loudest, Bell could not hear the faintest sound.

Was the telephone to fail? Watson feverishly adjusted the apparatus in every way he could think of, trying to make the telephone talk. But it was useless. He was about to disconnect the telephone and give up when he happened to think of another piece of apparatus. He attached it and the telephone was no longer dumb. Bell's voice was vibrating through it. "Ahoy!* Ahoy! Are you there? What's the matter?" Bell was getting hoarse shouting into the telephone. Watson ahoyed back and then began the first long-distance telephone conversation in the world.

The two young men were so fascinated with the idea of talking over a wire that they kept up the conversation until long past midnight. Then Watson walked proudly back to Boston with the telephone and his tools, wrapped in a newspaper, under his arm. When Bell and Watson got back to their boardinghouse there was great jubilation. They completely forgot that there were other people in the house and talked loudly and joyously over their achievement. The next morning, when Watson was on his way downstairs, he saw the landlady waiting for him at the door. From the expression on her face he knew that something disagreeable was in store for him. He pretended to be in a hurry, but the landlady stopped him with, "I don't know what you young fellows are doing up in the attic, but if you don't stop making so much noise nights and keeping my lodgers awake, you'll have to quit them rooms."

The next step was to bring the invention to the attention of the public. Bell realized that people would never use the

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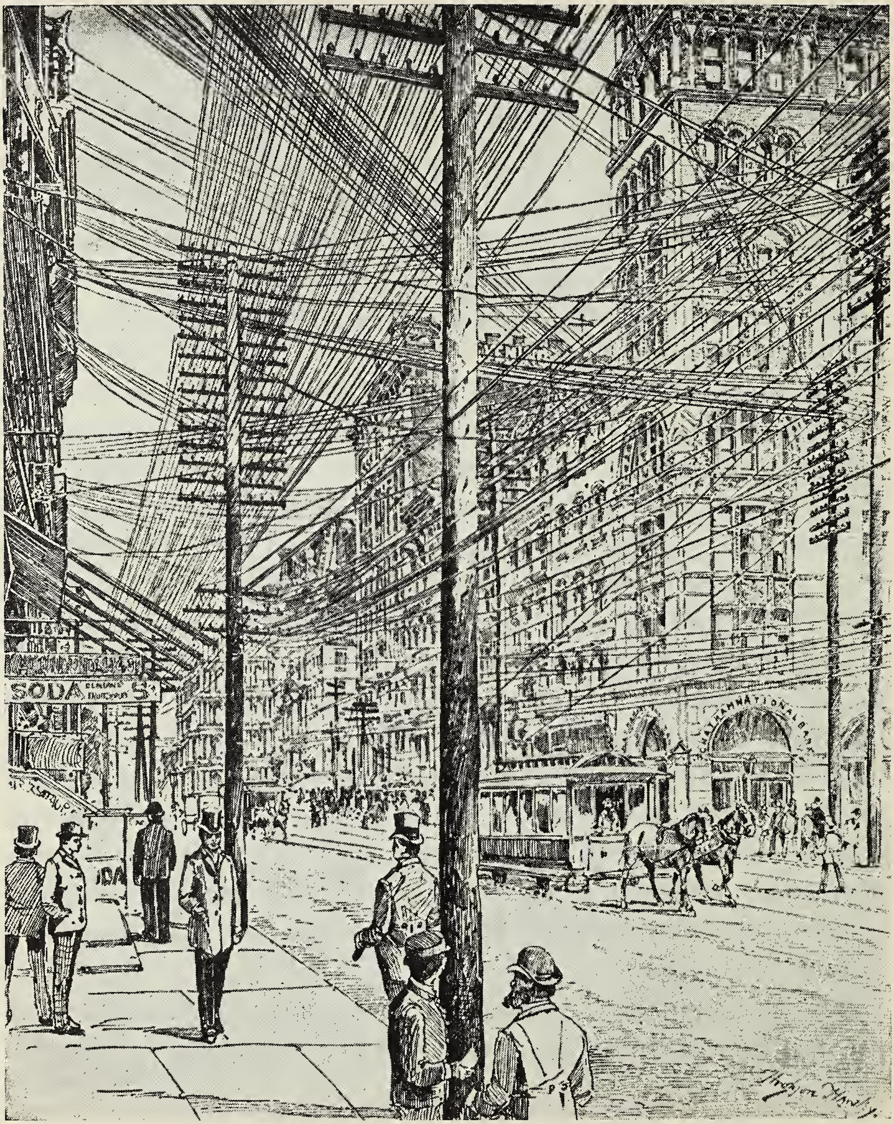
* "Ahoy!" was the word at first used to call a person on the telephone. Later it was changed to "Hello."



Courtesy New York Edison Company

Early telephone wires made a thick network over the streets.

telephone until they understood what it could do. So he and Watson went about, giving lectures and demonstrations, explaining the telephone. Bell would hire a hall in one city and give a talk about the telephone. Then he would bring forward his boxlike affair and explain it to the audience. Watson, installed in Boston, would shout with all his might into the transmitter.

"Good evening," the box would say. "How do you do?" "What do you think of the telephone?"

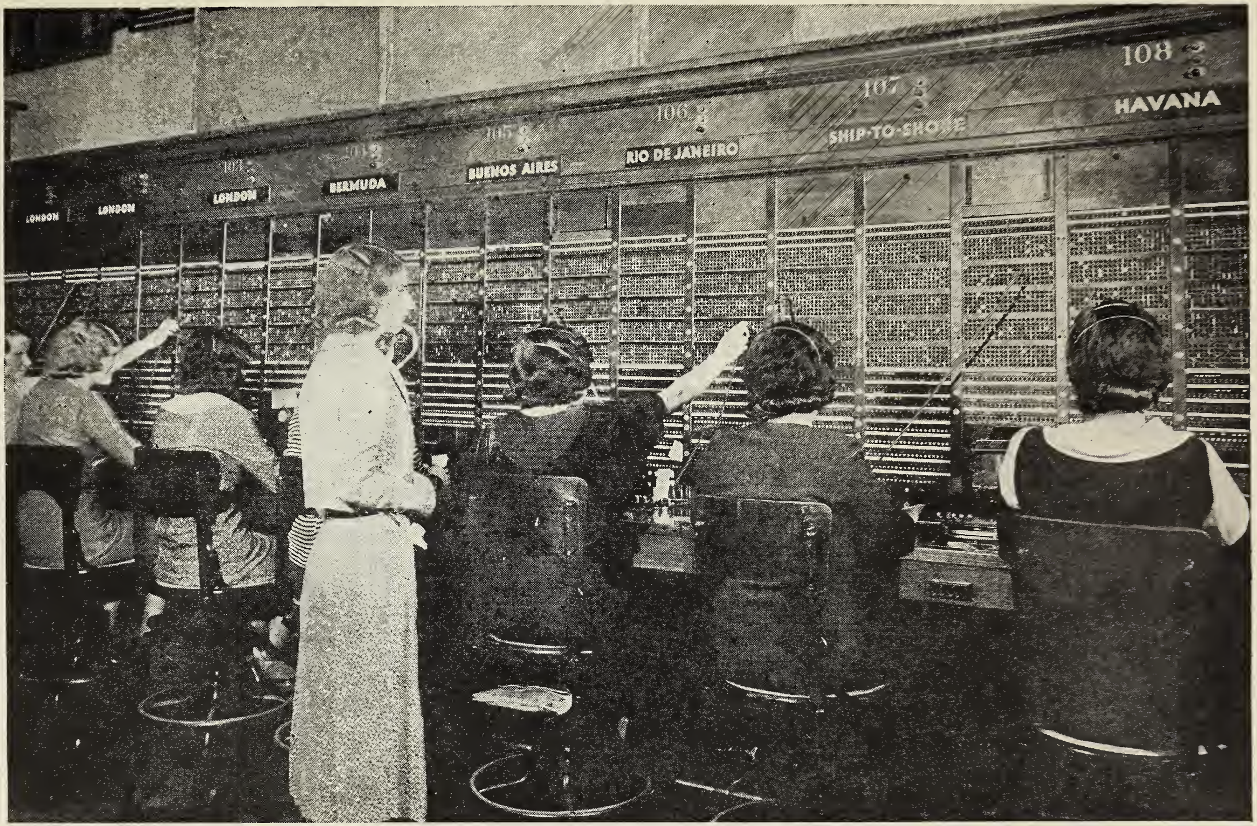
Then Watson would sing "Pull for the Shore," "Yankee Doodle," "Auld Lang Syne," and other popular songs. Afterward the members of the audience would be invited to test the telephone for themselves. The audiences were always delighted with these novel entertainments.

Bell decided that he would like to astonish New York audiences by having the connection all the way from Boston, although he was far from certain that sounds could be carried over such a long distance. To find out whether the plan was practicable, Bell and Watson made arrangements for a test. Bell went to New York and Watson remained in Boston. The trial of the telephone was to be made at midnight.

Realizing that he would have to shout very loud to have his voice carry to New York and remembering what the landlady had said about noise a few days before, Watson looked about for something to deaden the sound. He took the blankets off the beds and arranged them in a sort of loose tunnel with the telephone at one end. He waited for the signal announcing that Bell was ready. Soon it came, and Watson quickly wriggled into the tunnel of blankets and shouted into the telephone, through the still hours of the night. It was a hot, smothery experience, but the first soundproof telephone booth was a great success. No one in the boardinghouse heard Watson's voice.

In spite of all their efforts, it was difficult for Bell and Watson to make businessmen see the practical value of the telephone. They thought it was just an interesting, scientific toy and refused to invest money in it. Finally Bell and the few friends who had encouraged him through all his struggles formed the Bell Telephone Association to put the telephone on the market. Month after month the little Bell Telephone Company lived from hand to mouth. Other companies infringed upon Bell's patents and there were court actions, but finally Bell won.

Thus began the development of the telephone system, which soon became an important factor in communication.



Courtesy New York Telephone Company

At this switchboard telephone operators can connect a person in the United States with almost any part of the world.

CHAPTER XVI

Towering Cities

THE change in the way people worked, brought about by the Industrial Revolution, made great changes in the way they lived. One of the greatest of these changes was the growth of towns and cities.

Until the industrial age only a small number of the inhabitants of a country lived in cities; most people lived on farms, or in villages and small towns. But the factories of the nineteenth century needed employees who would not have to come a great distance to work. So all around these factory buildings, houses were erected in increasing numbers as more and more workmen arrived.

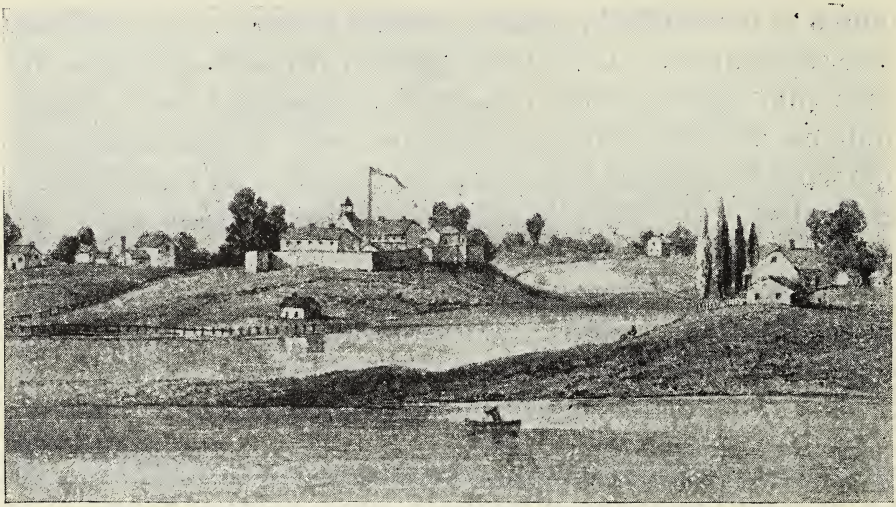
Busy factory workers, who had to be away from their homes all day long, could not find time to raise their own food or make their clothes; so other people began helping to provide these things for them. Stores were opened where they could buy food, clothing, and other things they needed. As more houses were built, the need grew for more stores, schools and churches, office buildings, banks, newspapers. Before long many people were living where only a short time ago there had been open country. Villages grew into towns, and towns grew into cities.

There is always some good reason why a city grew up just where it did. All over New England, where the factories were first introduced into this country, towns grew up like magic. In Pennsylvania and in the other states where coal and iron could be obtained easily other cities grew up. Pittsburgh, with vast fields of coal near by and excellent railroad facilities for the transportation of raw materials and the distribution of the finished products, became the first great center of the steel industry. Cleveland, halfway between ore and coal, grew into another center of activity in iron and steel. Gary, Indiana, is a city built up entirely by steel. Twenty-five years ago wind-blown sand dunes stretched south from Lake Michigan. Today in that place there are the towering stacks of blast furnaces and the smoke and flares from steel mills, with neat rows of workers' homes beyond the mills. Cities grew up in the wheat country—Milwaukee, Minneapolis, Kansas City, St. Paul, Omaha, Des Moines. Other cities, like Detroit, became automobile-manufacturing centers.

Chicago is a good example of a city which has grown up because it was close to supplies of the various products needed by many people. In 1830 Chicago was a little village of log houses with a population of perhaps a hundred and fifty. It was near a swampy river, and fur trading was the principal occupation. But a change was soon to come. Wheat and corn from Iowa and other Western states could be brought by train and boat to Chicago and from there distributed to other parts of the country. It is near the coal mines of Illinois and Indiana, and has excellent lake connections with the iron-ore districts of Minnesota. So Chicago became a central place of exchange for the food products; for coal, iron, and other raw materials; and for a great variety of manufactured goods.

Today it is a big city with a population of almost three and one-half million. On a railroad map you can see how Chicago is connected with every part of the country.

Good harbors account for the growth of many cities. Boston, New York, Philadelphia, and Baltimore are located almost exactly opposite to important European ports. Los Angeles, San Francisco, Portland, and Seattle have developed into large cities because they are favorably located for trade with the Orient.



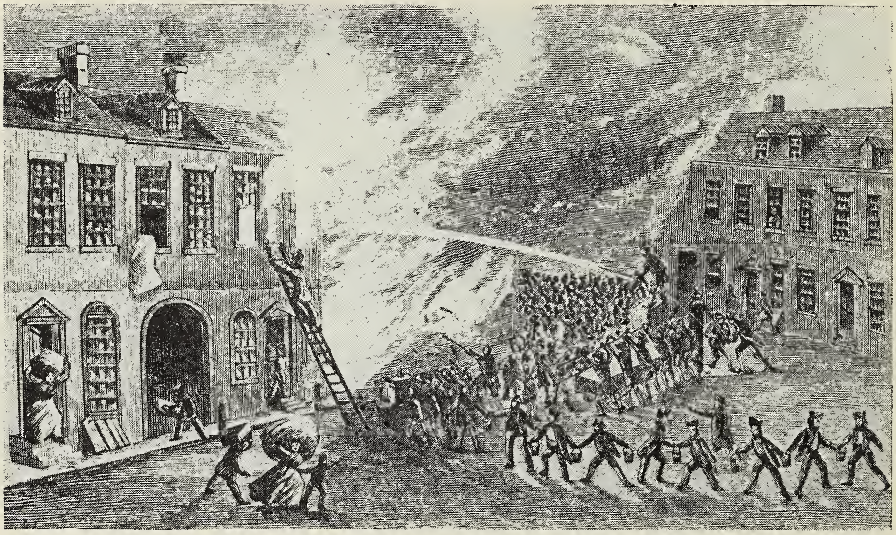
Chicago in 1831. Today it is a city of more than three million inhabitants. (From an old print)

Amazing has been the growth of New York City in the last century. The great vessels that cross the ocean can move only in deep water. In New York harbor the water is deep enough for the largest of them to lie close to the wharves. Vessels, when in port, must have protection from storms, and New York harbor is well protected by the bulging shores of Staten Island and Long Island. From New York an easy route leads westward into the heart of the country. New York is therefore the gateway to the continent. Almost half the imports and exports of the country pass in and out of its port.

So around the sources of power—coal, oil, or water—and the raw materials of industry, or at important transportation or trade points, or wherever large groups of people were needed to carry on work, cities grew. By the close of the nineteenth century the greater number of the people in the United States were living in towns and cities.

The rapidly growing cities brought many new problems to be solved. As cities grew, land became expensive, the amount of land the worker could own or rent for his home became smaller and smaller. Many families were crowded together in tenements. In some cities there were whole blocks of houses with little light and air. These were the homes to which weary workers came back after long hours of toil. In the days before the Industrial Revolution, when they lived in the country, they had had fresh air and sunlight, and every house had its little plot of ground and a garden; but in the cities they lived under unhealthful conditions, crowded together, with little air or light. Often there were no proper sanitary arrangements. There was no collection of garbage; refuse was thrown out into the streets and alleys. Even when New York was quite a good-sized city there was no regular street cleaning.

The streets of the early cities were poorly paved and poorly lighted. About 1850 lampposts were placed on the more important thoroughfares. After the discovery of oil in Pennsylvania, oil lamps were used and later gas. The only water available for early city dwellers was from wells or pumps. As the population of the cities increased, these were found to be insufficient and public waterworks were established.



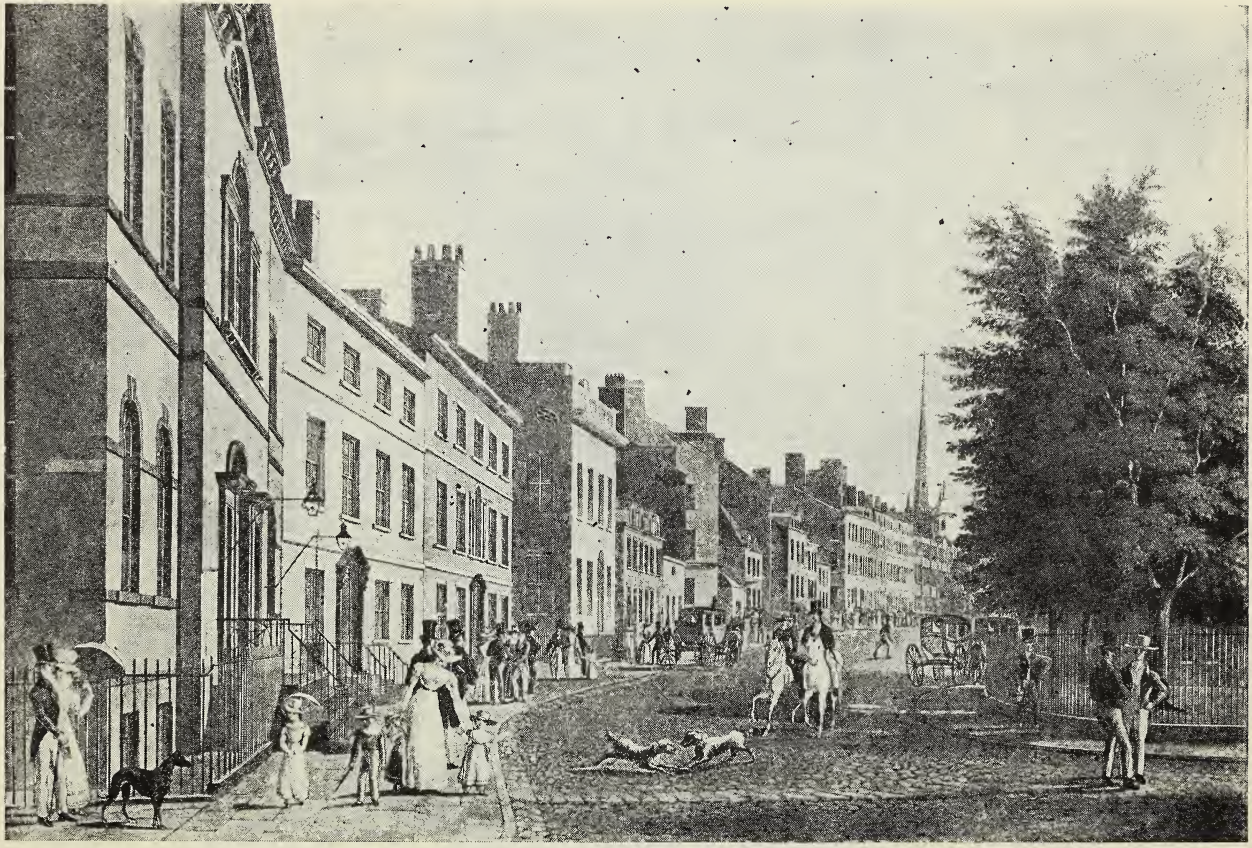
Early firemen putting out a fire with firebuckets. (From an old fire certificate)

There were no regular policemen. Laborers who worked by day acted as watchmen at night. After 1800 a regular police force was established in the larger cities. Early fire regulations were very simple. There were no regular fire companies. In case of fire every man helped his neighbor. The only way of putting out fires was by carrying water in buckets. Every family was required to keep in the front hall a number of buckets made of leather, each bucket marked with the name of the owner. When a fire broke out the buckets were set on the front steps, to be carried to the fire by the first passer-by, and their owners followed as quickly as possible. Soon two lines of men were formed, reaching from the fire to the nearest well or pump. Full buckets were passed along one line, and the empty ones passed back along the other. When the fire was over, the buckets were collected and taken in a cart to the city hall. The next day every householder sent for his buckets and hung them up again in the hall, ready for the next fire.

The cities needed officers to manage their various activities. They must be made clean, and healthful, and comfortable. Streets must be paved. Garbage must be disposed of. Public buildings must be put up. New streets must be opened up for homes or stores. Bridges must be built. There must be playgrounds and parks. Because these city-housekeeping duties meant a vast amount of work, each was placed under organized departments of the city government. A mayor, as the chief officer, was assisted by a board of health, a street-cleaning department, people to run the schools, policemen, firemen to safeguard the lives and property of citizens, and so on.

The cities brought, also, new problems of transportation to be solved. Until about the middle of the nineteenth century, when most cities were not much larger than small towns, stores and houses were close together, and people could easily walk to any part of the town. As they grew larger and people had to go farther and farther from their homes to their work and to stores and other places, they needed some cheap way of riding from one part of the city to another.

In some places omnibuses were tried. They were used in



New York City a little over a hundred years ago. (From an old print in the Stokes Collection in the New York Public Library)

New York as early as 1830. Then came streetcars. Horses with tinkling bells pulled these little cars along iron tracks laid along the middle of the street. In the wintertime the shivering passengers tried to keep their feet warm by thrusting them into the piles of straw that were heaped up on the floor.

But these cars were not fast enough for the people of our rapidly growing cities, and soon the cable car was invented. This car was pulled along by a strong steel cable that ran under the street. The car was hooked on the cable by a steel clamp, which ran from the bottom of the car through a slot in a trench dug down under the ground. Cable cars were faster than horsecars, but they were very expensive to run.

After the dynamo came into use, men learned how to employ electric current to turn the wheels of cars. The first cars run by electricity were trolley cars. The trolley wires, strung on poles high over the track, carried the electric current made by the whirling dynamos in a powerhouse. The long iron pole on the roof of the car, with its little wheel running along touching the wires, brought the electric current into the car's motor and made the wheels turn. But it was dangerous to have so many poles and wires overhead. Someone invented another way of carrying the electric current by means of a third rail under the ground between the tracks.

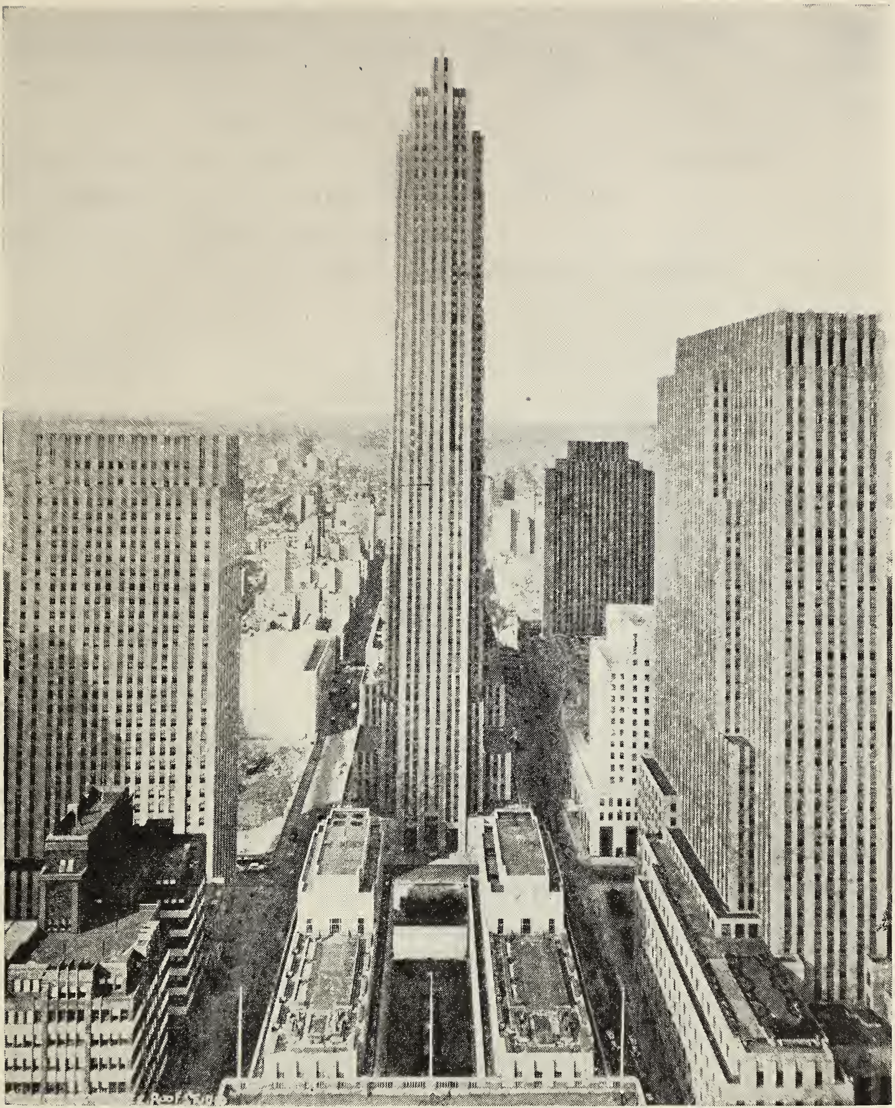
But in spite of these improvements transportation in the larger cities became more and more difficult. At certain hours of the morning and evening the streets were crowded with people trying to get to and from their work as quickly as possible. Surface cars could not take care of these great crowds. In some cities tracks, supported by iron posts, were built high up above the streets. These were called elevated roads. The surface cars could go along the street while the elevated trains ran overhead.

New York City had the first elevated road in the world. In 1767 Charles Harvey received permission to build such a road and took the first trip over it himself in a little car run by steam. It was several years, however, before this road was a real success. By 1875 the steam engines were discarded and electricity was used as motive power.

Only a few cities have elevated railroads. In New York and some other cities long tunnels have been made under the streets and tracks laid in them, with station stairways leading down to the tracks. In these subways, as they are called, long trains of cars can speed under ground, taking many people quickly from place to place.

In the larger cities land grew more and more valuable every year, and buildings were built higher and higher to make the most of the ground space. It is tiring to climb stairways, and people do not like to go up more than four or five flights of stairs. Men began building elevators to carry them up and down in the tallest buildings. In the early elevators there were sometimes bad accidents when the cable broke. In 1853 Elisha Otis of New York invented an elevator run by electricity, which made riding much safer. With safe elevators it was possible to build higher buildings.

Until 1893 all buildings were made of brick or stone and could not be built higher than eight or nine stories. Then steel came into use and with a framework of steel, anchored deep in the rock below the surface, it was found that buildings could be erected to almost any height. Thus a new kind of building, the skyscraper, which could house hundreds of peo-



Courtesy Rockefeller Center Inc.

Rockefeller Center, one of New York's most modern and most beautiful groups of skyscrapers.

ple on a small plot of ground, grew up in many cities. In New York, where some of the tallest skyscrapers are, some buildings are more than a hundred stories high.

A century ago this country was a country of farms and villages. In 1790 only three people out of every hundred in the United States lived in cities; today the United States has become a nation of city dwellers.

CHAPTER XVII

A New Light for the World

In the early days of the nineteenth century the best-known methods of lighting were by kerosene lamps or by dim, flickering gas. A great problem of the time in the rapidly growing cities was how to use electricity to light homes, offices, factories, streets, and public buildings. Then came a great inventor, Thomas Edison, who made this possible.

Many interesting stories are told of Edison's boyhood. When he was twelve years old he began his career by starting out as a railway newsboy on the Grand Trunk Railroad which ran from Port Huron to Detroit. Edison was just the kind of boy to enjoy spending his days on a train. The busy, varied life he led there was an education to the quick-witted, wide-awake boy.

Edison had some free time on the train and he began to think he would like to print a newspaper. So he bought an old printing press and some used type from the *Detroit Free Press* and set up a printing office in a corner of the baggage car. There he spent all his spare time working on a little paper called *The Grand Trunk Herald,* which he issued weekly and of which he was editor, business manager, reporter, and printer. It contained much news of interest to those connected with the railroad, such as changes in time, the stagecoach connections with the train, announcements of articles lost and found, and so on, and it had a wide sale. The fourteen-year-old boy was printing the only newspaper in the world published on a train.

Here are two excerpts from one of the issues. Notice the grammar, punctuation, and spelling.

"The More to Do the More Done:—We have observed along the line of railway at the different stations where there is

Courtesy New York Edison Company

Thomas Edison as a boy.

only one Porter, such as at Utica, where he is fully engaged, from morning until late at night, that he has everything clean and in first-class order, even the platforms the snow does not lie for a week after it has fallen, but is swept off before it is almost down, at other stations where there is two Porters things are visa versa."

"Premiums:—We believe that the Grand Trunk Railway give premiums every six months to their Engineers who use the least wood and oil, running the usual journey. Now we have rode with Mr. E. L. Northrop, one of the engineers, and we do not believe you could fall in with another Engineer, more careful, or attentive to his Engine, being the most steady driver we have ever rode behind (and we consider ourselves some judge haveing been Railway riding for over two years constantly,) always kind, and obligeing, and ever at his post."

The newspaper had a sad ending. One day Edison got hold of an old chemistry book which excited him very much, with its wonderful accounts of such ordinary things as air, water, and fire. He was curious to experiment with some of the strange elements mentioned in it. He thought it would be interesting to have a laboratory, fitted out with materials for making chemical experiments. So he bought some second-hand apparatus with money he had saved, and a few of the cheaper chemicals. These he arranged on shelves in the corner of the freight car where his newspaper office was. In his little laboratory on the jolting train the inventor spent all his spare time making experiments. He found it a fascinating experience.

One day Edison was working away, when, alas! as the train was passing over a rough stretch of road, a bottle of phosphorus fell from its shelf and broke. Suddenly the chemical burst into flames and soon the car was ablaze. The fire was put out before it had done much injury, but the conductor was excited and angry. He declared that he would have no more of the dangerous stuff on his train, and he threw the whole outfit, including Edison's printing press, out of the car. The owner protested with some spirit and the conductor picked him up and threw him out also; and Edison found himself walking the station platform rubbing his recently boxed ears. So that was the end of Edison's job on the train and of *The Grand Trunk Herald*.

Poor Edison went to work picking up what was left of his precious things, planning where he would reopen his laboratory. He decided that his father's basement would be the safest place. Before many days had passed he had made good his loss by new purchases and had begun experimenting on a larger scale than ever. To make sure that no one interfered with his materials he marked on every bottle POISON. DON'T TOUCH.

Just a few weeks after this, something occurred which had a great influence on Edison's afterlife. One day, while he was standing on the station platform, he saw the station agent's little two-year-old boy playing on the railroad track. A heavy freight train was coming toward the child. With a flying leap young Edison sprang out on the track and, at the risk of his life, dragged the baby out of reach of the wheels without a second to spare.

When the child's father heard about this he would have been glad to reward the brave boy who had risked his life to save his child, but as he was a poor man and had no money he offered instead to teach Edison telegraphy. Nothing could have pleased Edison more, for electricity fascinated him. The lessons were begun at once. The young telegrapher came regularly and made such surprising progress that he was soon as good an operator as anyone along the line.

Before he was sixteen years old Edison had obtained a position as a night telegraph clerk at a salary of twenty-five dollars a month. His job kept him busy at night, and he did not sleep much in the daytime as he was too busy then working on his own schemes. He was required to signal the word "six" to the managers of the road every half hour, but sometimes he would fall asleep in his office. So one day he invented a little machine, which he attached to a clock, to do his work for him. When the manager of the road learned about the machine Edison lost his job.

He secured another position as telegrapher. He was an excellent operator but he loved experimenting, and he would become so absorbed in working out his own ideas that often he would forget his duties. He spent several years roaming from one town to another in the Middle West, securing positions and in a little while losing them again because he could not overcome his impulse to invent.

In the autumn of 1869 Edison decided to try his fortune in New York, and arrived there almost penniless. As he had no money for lodging, he was allowed to stay in the building of the Gold and Stock Telegraph Company, from which information of the buying and selling of stocks was sent out to all the brokers in the city.

One day the complicated instrument that sent out the messages came to a standstill. Something had gone wrong. If the trouble was not remedied at once, many businessmen would lose money. Nobody seemed to know what to do. Everything was in the wildest confusion. Edison made his way quickly to the office of Mr. Laws, the vice president of the company.

"I think I can show you where the trouble lies," he said quietly.

He was given permission to try, and in a short time he had repaired the damage. He was called to the office of the president and offered charge of the whole plant, with a salary of three hundred dollars a month. What a change of fortune for the poor lad who had drifted to the city penniless a short time before!

A few years later an invention of Edison's which improved the ticker was brought to the knowledge of the president of the company. Edison was asked how much he would take for it.

"I had made up my mind that, taking into consideration the time and killing pace I was working at, I should be entitled to $5000," Edison tells us. But he lost courage and said, instead, "I think I will let you name the price, sir."

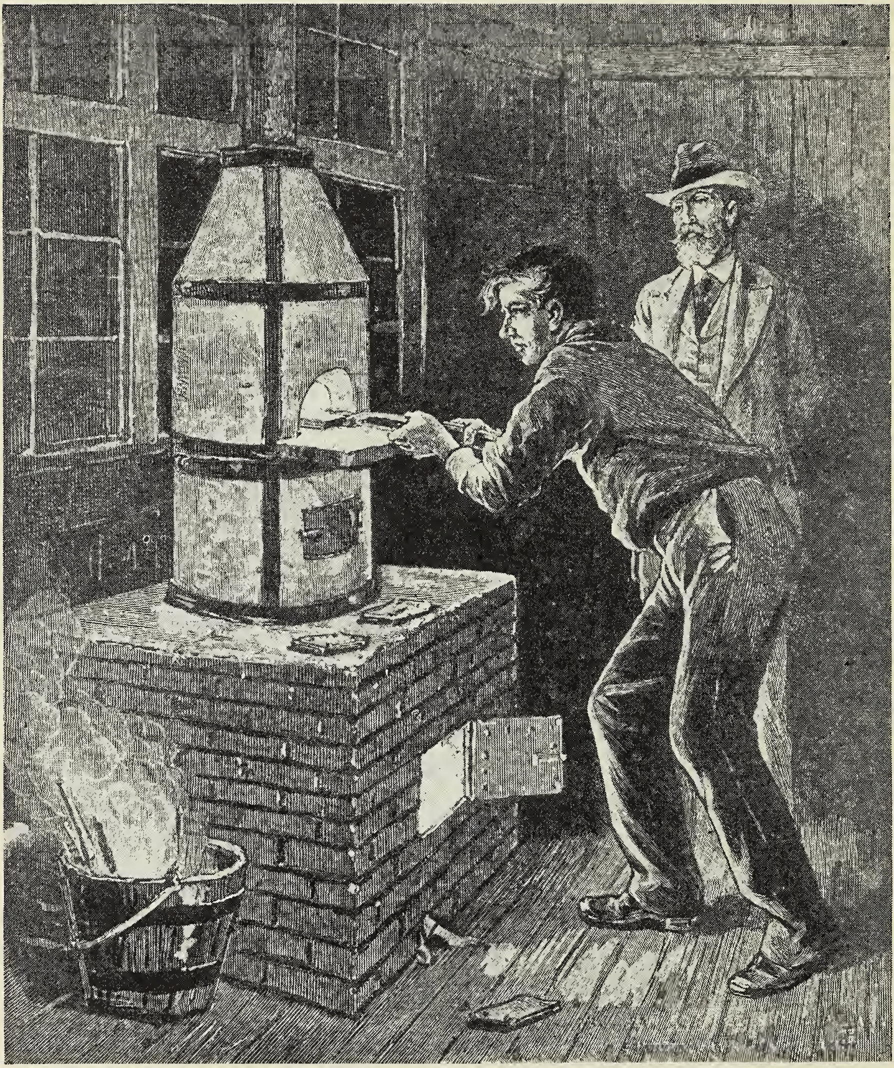
"Well, how would forty thousand dollars strike you?" asked the president. Edison was handed a check for the amount and staggered out of the office, stunned by his sudden good fortune.

Now Edison had money enough to experiment to his heart's content, and he decided to devote his whole time to inventing. He built a large laboratory and secured assistants to help him work out schemes which had been in his head ever since he was a boy. In his laboratory at Menlo Park, New Jersey, he began his long career of study, experiment, and work which resulted in inventions that later astonished the world. During those busy, happy years he often worked in his laboratory until three or four o'clock in the morning, sometimes taking little naps on one of the tables with a few books piled up for a pillow.

Although Edison made many inventions, his greatest contribution to the world was the electric light. He was not the first man to make one. An electric arc lamp had been invented, but it was too large and too expensive for ordinary use. Edison realized that a small electric light for buildings and homes was the great need of the time, and the idea of making one took possession of him.

For many years scientists had known that electricity heats the wire through which it passes, and some had tried to make an electric light by having a strong current heat a fine wire until it glowed. But these wires burned up quickly. The young inventor worked patiently and tirelessly testing one material after another. He tried using wire made of platinum, a very hard metal, but even this melted when the electric current had passed through it for a short time. Then he began testing vegetable materials. He said he would try everything until he found the right material.

One day, in 1879, Edison sent for a spool of cotton thread. Cutting off a suitable length, he bent it into horseshoe shape, clamped it between two blocks of nickel, and placed the blocks in an oven. After five hours he took the blocks out, let them cool, and looked at the filament. It had changed to carbon. When he tried to pick up the fragile filament, it instantly



Courtesy New York Edison Company

Young Edison carbonizing a thread for his electric light.

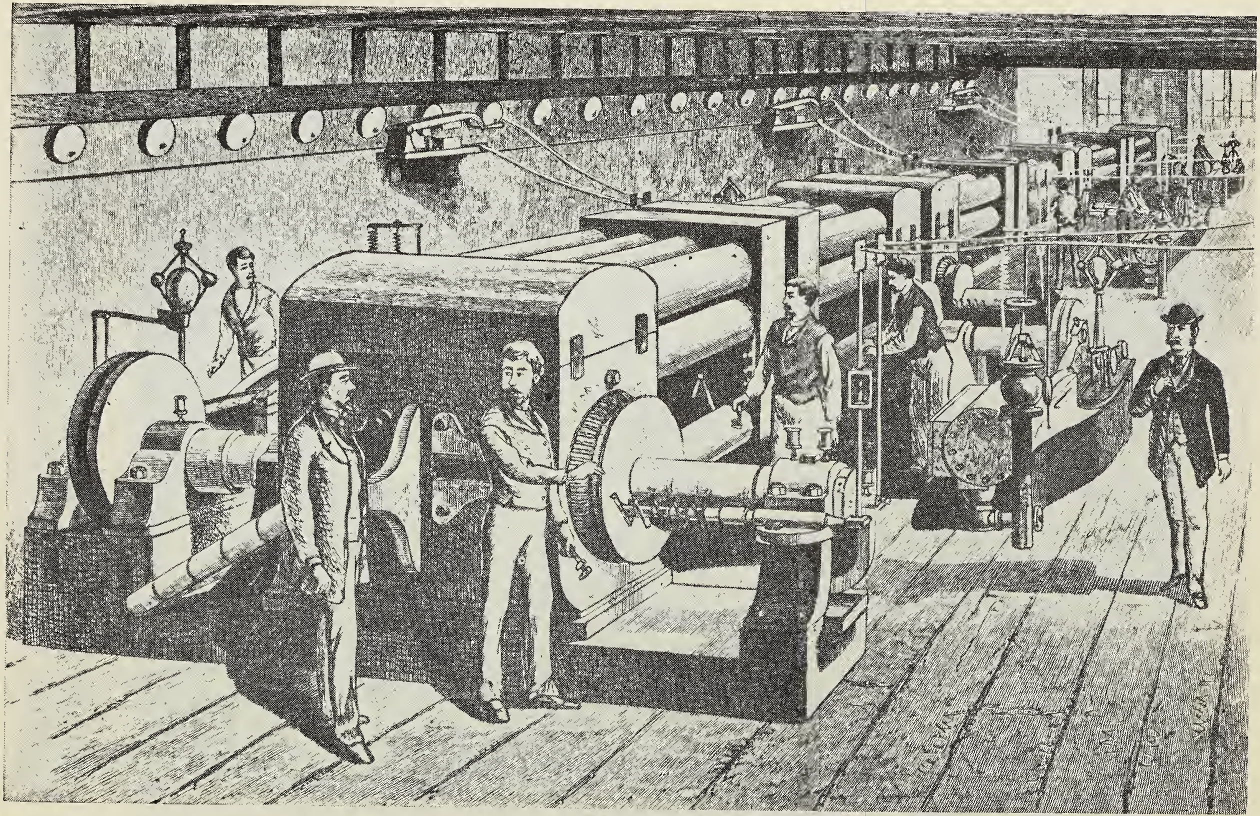
broke. Another thread was tried. It broke. For two days and two nights Edison worked without sleep, trying to get a carbonized thread which would not break. At last he succeeded in getting one into a bulb from which the air had been pumped out. He carefully turned on a gentle current. There was a faint glow. If he turned on a current stronger than that which had melted the platinum wire, would the light still glow? He tried a stronger current, and a beautiful, clear light greeted his eyes—brighter than any that had been seen up to that time. You can imagine Edison's delight.

But how long would the light last? That was the all-important question. Fascinated, Edison and his helpers watched the little glowing light, hour after hour, to see how long it would last. "We sat and looked," said Edison, "as the lamp continued to burn. The longer it burned the more fascinated we were. None of us could go to bed and there was no sleep for forty hours. We sat and just watched it with anxiety and growing elation."

After burning for forty hours the little carbonized thread suddenly went out. But Edison was satisfied, for he knew that he had solved the problem of the incandescent light. He said, "If it will burn that number of hours now, I know I can make it burn a hundred."

Then Edison began carbonizing everything he could lay his hands on—all kinds of twine, grasses, and fibers, to find the best kind of carbon for the filament. Month after month he worked, but none of his experiments produced the result he wanted.

One day, as he was walking about in his laboratory, he noticed on his desk a palm-leaf fan bound with bamboo.



Courtesy New York Edison Company

The first power station in America, built by Thomas Edison in 1882 on Pearl Street, New York.

Quickly he tore off the strip of bamboo and handed it to one of his assistants. "Test that," he said. The test proved that bamboo was the best material thus far discovered.

Edison learned that there were more than a thousand varieties of bamboo and decided to find out where the best variety grew. Thousands of miles up the Amazon River in South America went one of his men, searching and testing. Through China, India, and Japan went others. Finally from the jungles of the Amazon was obtained the best kind of bamboo for the lamp.

Courtesy New York Edison Company

A night view of New York City showing some of the world's tallest buildings lighted by electricity.

By 1880 Edison was ready to give his new invention to the world. He decided to give a demonstration in his home.

Rows of lamps were strung from the trees on the grounds at Menlo Park. The laboratory was aglow inside with dazzling lights. Special cars were run from New York and crowds of people went to see the display of the wonderful new invention.

Edison saw that his lamps would be of no use without dynamos and central power stations to supply the electric current for them. In 1882, after much experimenting, he built on Pearl Street, in lower New York, a central power station, from which the electric current could be sent out to buildings and homes.

The Edison Electric Light Company was formed, other power stations built, and soon cities and towns everywhere had bright electric lights instead of the dull oil and gas lamps that had been used up to that time.

CHAPTER XVIII

Machinery Comes to the Farm

UP TO the nineteenth century, farming had changed but little since ancient times; because of the slow methods of getting food, most people had to be farmers. The age of machines was producing towns and cities, and people flocked to them to engage in the new industries that were everywhere springing up. These people, at work all day, could no longer raise their own food. How, then, could these city dwellers be fed? The explanation is that, during the time in which industry was changing from handwork to machine work, methods of farming were being so transformed that a few people could raise enough food for many.

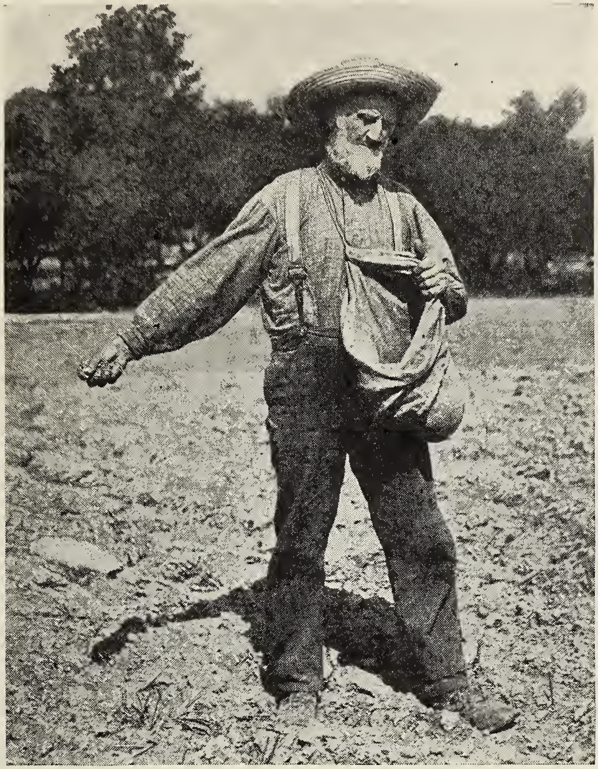
One of the greatest discoveries early man made was that he could plant seeds in the ground and raise food. Nobody knows when and how man learned to do this. Possibly seeds of wild plants that these early people liked to eat may have been blown by the wind near the caves where some of them were living and they may perhaps have noticed that new plants grew up where these seeds had fallen in the soil. This may have given them the idea of gathering seeds and planting them themselves.

After a long time men discovered that seeds grew better if the ground around them was broken up. They invented the plow. The first plow was probably nothing but a forked limb of a tree, sharpened at the end and dragged along the ground to make a furrow. This was very hard, slow work, and men found, as time went on, that they could greatly lighten their labor by hitching horses or oxen to their plows.

Courtesy International Harvester Company

Up to the early part of the nineteenth century the plow used by farmers was not very different from that used by the early Egyptians.

We do not know in which country people first began to plow the ground, for there are no records to tell us; but we do know that thousands of years ago the Egyptians had learned to do this, for they made pictures on the walls of their temples showing men plowing. From these we can tell what the ancient plows were like.



Courtesy International Harvester Company

An old-time farmer sowing seed by hand as the ancient Egyptians did.

Many centuries passed before there were any improvements in the plow. In colonial days in our country it was still the clumsy, wooden thing it was in the early days of the world. About the year 1797 Charles Newbold, of New Jersey, succeeded in making an iron plow, but most farmers would not use it. They thought that the iron would poison their crops. A little later Jethro Wood, of New York, made an iron plow and in the course of time it came to be widely used.

Of all the plants farmers raise, wheat, from which bread is made, is the most important. In the spring horses, mules, or slow-moving oxen were hitched to a plow and up and down the fields they went, turning up the long furrows of rich, brown earth, preparing it for the seeds. Then with a bag of seed slung over his shoulder, the farmer walked on the soft, crumbly earth, and, with a wide sweep of his arms, scattered the seeds over the soil.

The seeds lay in the ground until the warm air, the sunshine, and the showers of spring started them growing. Then the brown fields were covered with a green, velvety carpet. The spring days passed and the plants grew taller. The head of each stalk grew heavy with little seeds. Gradually the grain changed from a soft green to golden yellow, and in August the fields were beautiful with waving acres of grain.

When the grain was ripe it had to be cut immediately, or it spoiled. Time was precious. When harvesttime arrived the family of a farmer and all the extra helpers he could hire had to work hard in the fields while the sun poured down its burning heat on their backs.

The tools used by farmers for cutting grain were not very different from those that had been used for centuries. In the early days of the world a short, curved knife fastened to a handle was used for cutting grain. It was called a sickle.

The handle of the sickle was so short that a man had to stoop low to do the cutting. This was very tiring. Later someone invented a scythe, which had a long blade and a long handle.

Cutting wheat with the sickle in colonial days.

The scythe was an improvement on the sickle, as men need no longer bend almost double over their work. But it was not very satisfactory for cutting grain, as it strewed the stalks all over the ground.

In 1806 a farmer in New England invented a cradle. This was a framework of long wooden fingers attached to a scythe. The fingers caught the stalks of grain as they fell, and left them on the ground, neatly arranged in piles, which could be easily bound into sheaves. The cradle made the gathering of grain much quicker, but even with its help the amount of grain that could be cut was still small.

The cradle was a great improvement over the sickle.

Men, both in England and the United States, had tried to make a machine that would reap grain, and thus do away with the slow, backbreaking work in the harvest fields; but no one had been able to construct one that worked well.

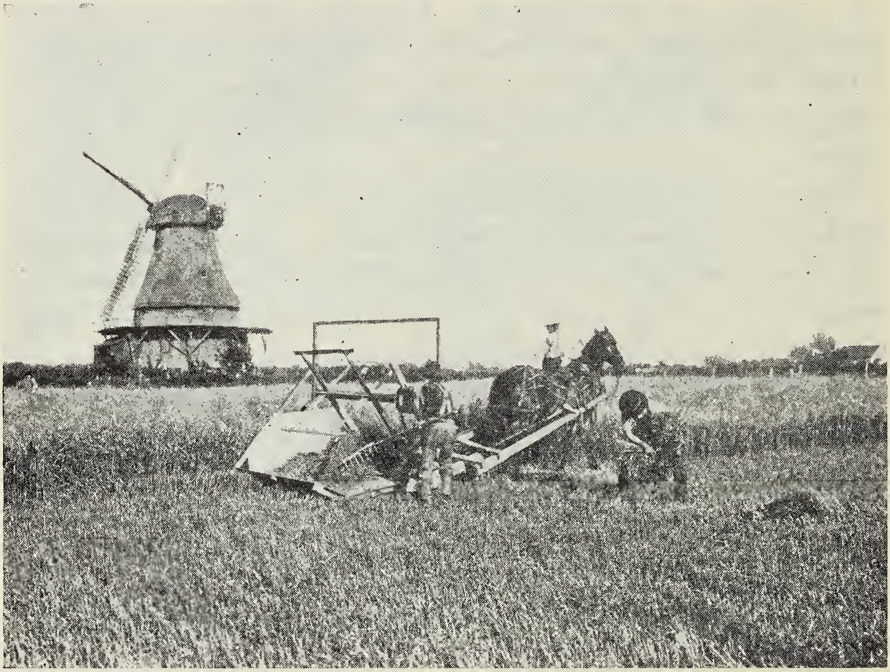
For years Robert McCormick, a farmer in Virginia, had tried to make a mechanical reaper. He succeeded in constructing one that cut the grain, but it flung it in tangled heaps on the ground. He could not discover how to improve his machine and finally gave up trying.

While Robert McCormick was working on his reaper, his son, Cyrus, was growing up. He had watched his father's efforts to perfect a machine and, after experimenting in his father's workshop, came to believe that he could make one. He had some ideas entirely different from any used by his father.

Cyrus set to work in an old log blacksmith shop and with the help of Jo Anderson, a faithful negro slave, fashioned the wood and iron parts for his reaper. A near-by blacksmith made to the boy's order a knife with a saw-toothed edge. Young McCormick had an idea that if he could hold the grain up to this knife it would cut just as a saw cuts. To hold the grain up to the knife and lay it down smoothly after it was cut he planned a revolving reel. Back of the knife he built a platform on which the grain would fall after it had been cut and from which it could be raked off. He had to work for a long, long time before he was able to construct a satisfactory machine.

It was only during the harvest weeks that the machine could be tried out. The young inventor worked feverishly to finish his reaper in time for the harvest of 1831. At last, one day in July of that year, the reaper was ready for a trial. Cyrus drove his cumbersome machine into the field and his whole family looked on as it made its way through the grain. The machine worked with hitches, but it did work. There was much rejoicing in the family. McCormick then drove it back to the shop to make certain improvements in it.

A few days later Cyrus was ready to try his machine again. He made arrangements with John Roff, a farmer who lived near the town of Lexington, about eighteen miles south of his home, to exhibit the reaper in his field. Farmers and farm hands for miles around, men whose backs were bent and whose hands were scarred with the drudgery of harvesting, laid down their sickles and cradles and gathered to see what could be done by the new-fangled machine.



Courtesy International Harvester Company

One of McCormick's early reapers.

It was a strange sight which met their eyes. Never had they seen anything like this contraption. The young inventor, tall, square-shouldered, strode behind the reaper. Jo Anderson, the negro slave who helped him build it, walked beside it, rake in hand, keeping the platform clear of the cut grain. The old farmers gazed, scarcely able to believe their eyes, as they watched the reaper lay down the grain in wide swaths.

Unfortunately, the field in which the trial was being made was hilly and rough, and the machine jolted up and down over the bumps. John Roff, the owner of the field, grew worried.

"Here!" he shouted, rushing up to McCormick in great excitement. "This won't do. Your machine is ruining my wheat."

The farm hands, who were afraid that the new machine would take away their work, were delighted.

"It's a humbug," said one.

"Give me the old cradle yet, boys," cried another.

Just then a man who had been watching the reaper came to McCormick's rescue.

"I'll see that you get a fair chance, young man," he said. "That field of wheat on the other side of the fence belongs to me. Pull down the fence and cross over."

The offer was quickly accepted. The field was fairly level and the reaper worked well. Around and around it went, and the grain fell in a golden shower on the platform. Jo Anderson, half-running to keep up with the machine, raked the cut grain from the platform.

For the first time in history a machine had successfully cut grain. Before sundown it had cut six acres, which was as much as several men could have done by swinging the old-fashioned cradles. The farm hands who had made fun of the reaper had to admit that Cyrus had succeeded.

Robert McCormick was very happy at his son's success. When Cyrus arrived home that evening his father said, "Your reaper is a success, and it makes me feel proud to have a son do what I could not do."

After this Cyrus devoted all his time to making reapers, turning them out by hand in the blacksmith shop; but for several years no one would buy one. The prevailing opinion seemed to be that the reaper was "a right smart curious thing, but it won't come to much."

In the meantime, as a result of the panic of 1837, Robert McCormick lost all his money and had to give up his farm. But Cyrus would not give up his reaper. No one would have taken it if he had. Most people would have been discouraged by such misfortune and would have given up, but McCormick worked harder than before. At last, in 1842 he succeeded in selling seven reapers; in 1843, twenty-nine; in 1844, fifty.

Several of the orders for reapers came from the West, and then arose the problem of getting them out there. The trip by wagon and boat was a long one, and in some cases the farmers did not receive their reapers until after the harvest.

McCormick saw that he must build his reapers in a more central place; so he decided to go West to look about. He traveled by stage through Pennsylvania, by boat along the Great Lakes, and on horseback through the Middle Western states. For the first time in his life he saw the beautiful prairies, so broad and level, with their wonderfully rich soil. He saw long lines of men in the fields, their arms endlessly swinging the heavy cradles through the grain. On the fertile prairies the grain grew so bountifully that there was too much for the laborers to cut, and many fields were left unharvested. Here, surely, thought McCormick, was a country made for the reaper. He settled in the little frontier town of Chicago.

Cyrus McCormick was not only an inventor; he was a good businessman as well. He studied carefully the problem of selling his reapers. It cost a good deal to make a reaper and few farmers could afford to pay the price that McCormick asked. So he offered them credit until they could pay for them out of the profits of their harvest. As he had no money to develop his business he had to find a man with capital who would become his partner. This he did, and in 1847 a factory was built. Thus McCormick was able to make reapers on a large scale. In two years he bought out his partner and was well on his way to a fortune.

The reaper, much as it did for agriculture, was still not enough. It cut the grain and threw it on a platform at the rear of the machine, from which a man raked it off when enough had been cut to form a bundle. The bundles were left on the ground for other men to bind. Inventors were trying to think of some method of speedier binding. Soon came a self-binder. With it the grain was gathered into sheaves and neatly tied without the aid of human hands. The last step in the development of harvesting machines was the combine, which cuts, winnows, and threshes the grain.

Many other improvements were made in farm machinery. The sod of the vast prairies could not be broken quickly enough with a plow of a single share. About the middle of the nineteenth century the gang plow was invented; this had several steel blades, arranged side by side, by which several furrows could be made at one time. A seed-sowing machine was also invented. This was a long box, mounted on wheels. Under the box were small tubes. The box was filled with grain and drawn back and forth over a field. As it moved, the grain trickled out of the tubes in rows from six to eight inches apart. In front of each tube was a tiny scraper which opened a place for the seed, and behind each tube was a little device that covered the seed with a thin layer of dirt.

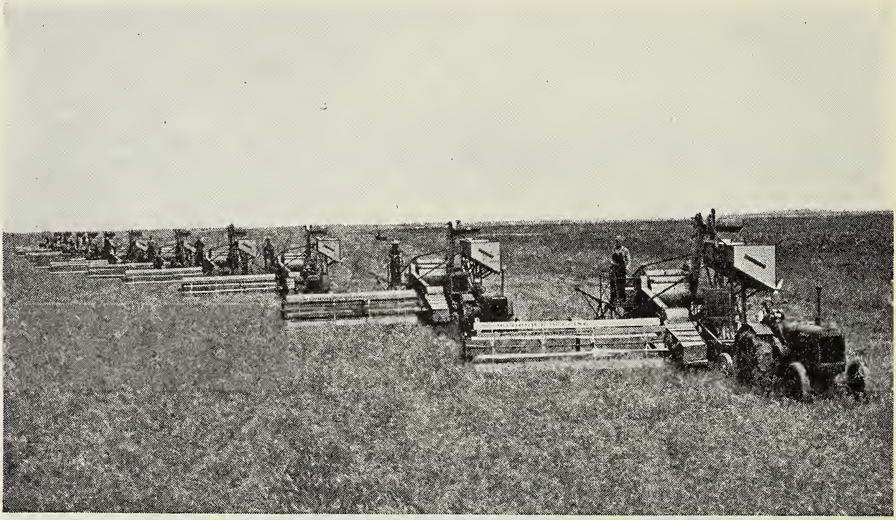
Courtesy International Harvester Company

Comfortably seated in his gasoline tractor, the modern farmer guides his gang plow, which cuts several furrows at the same time.

For a long time horses or mules were used to draw these new machines. Sometimes thirty or forty mules or horses were needed to drag the heavy combines through the fields. Animal power had reached its limit, and machine power had to be found to do the pulling. In the nineteen-hundreds came the tractor. A tractor is a machine driven by a gasoline engine, like an automobile. It will pull all sorts of machines. Today, on the large, up-to-date farms, the farmer does practically all his work with a tractor.

On some farms twenty to thirty horses or mules were needed to haul the machines through the fields.

All sorts of other machines have been invented to help the farmer in his work. Their use has made it possible to utilize to the full the great agricultural regions of the world. Farm machinery has also been very important in building up our modern industrial civilization. Without it our great, populous cities of today could never have come into existence.



Courtesy International Harvester Company

Twelve harvester threshers working in a field.

Suppose people were still plowing, planting, and threshing with the crude implements of a century ago, and still harvesting with the sickle and cradle. It is easy to see that the millions of people now engaged in producing the comforts and conveniences of modern life would have to be working in the fields to keep from starvation.

CHAPTER XIX

The Horseless Carriage

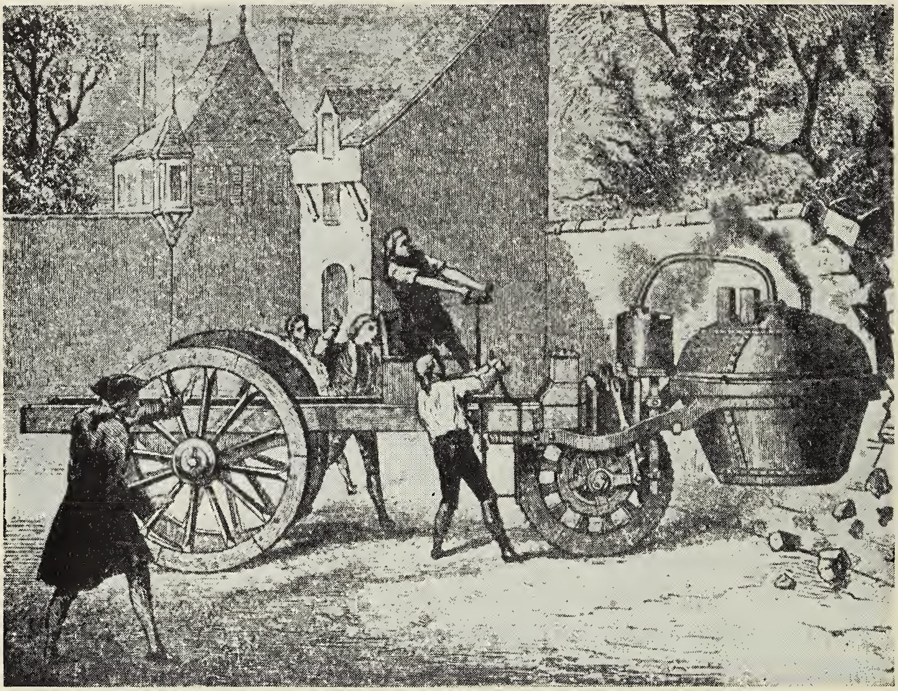
DURING the early days of the railroad, when inventors were experimenting with locomotives, men were also attempting to make steam-driven vehicles that could be used on ordinary roads.

As early as 1769, the year in which Watt invented the steam engine, a French inventor, Nicholas Cugnot, ran a strange-looking engine on the streets of Paris at the rate of three miles an hour. It had only three wheels. At the front was a large, round, copper boiler, like a steam kettle, connected by pipes with two cylinders over the single front wheel. Its supply of steam lasted only fifteen minutes. Then it had to stop until it could get up enough steam to go on.

Several trials were made with this engine. It proved to be difficult to steer. One unlucky day it ran into a stone wall and knocked a great hole in it. Another day, when it was turning a corner while running at full speed, it lost its balance and fell over with a crash, scalding some bystanders with its steam. After that it was considered too dangerous to be run, and France passed a law forbidding steam engines on roads or streets.

Inventors in England also took up the problem. In 1801 Richard Trevithick built a steam carriage to be used on roads.

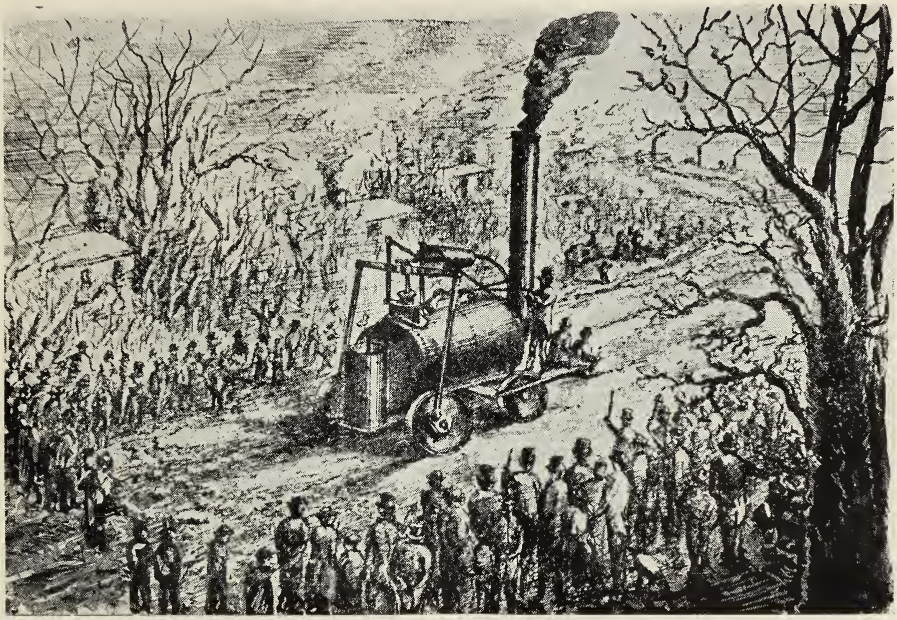
At Christmas time of that year the good people of his neighborhood saw a strange vehicle rattling along the road. Old Stephen Williams, one of them, tells about it: "On Christmas Eve, coming on evening, Captain Dick got up steam out on



The forerunner of the automobile, invented by Nicholas Cugnot in 1769.

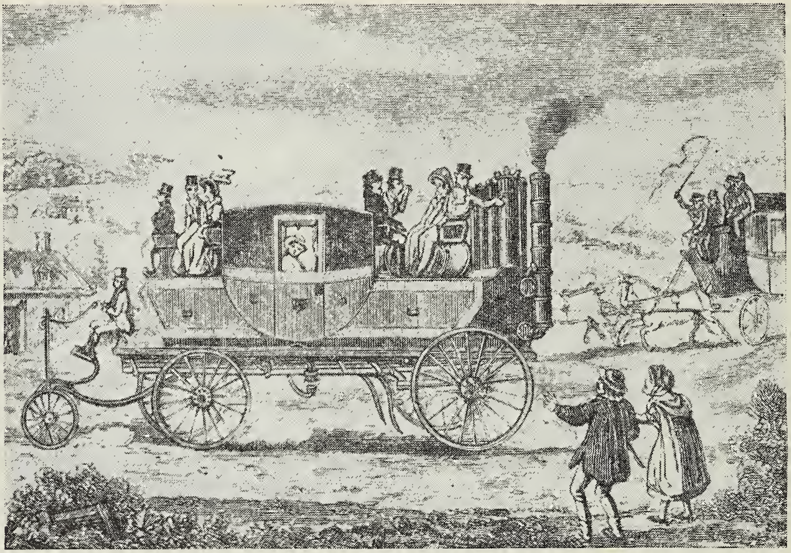
the high road. When we see'd that Captain Dick was a-goin' to turn on steam, we jumped as many as could, maybe seven or eight of us. 'Twas a stiffish hill, but she was off like a bird."

Other inventors in England were fired with the ambition to make steam serve transportation over highways and a number of steam-propelled vehicles were built. In 1824 W. H. James built a passenger coach. Another builder of steam carriages was Walter Hancock, who operated two steam carriages, carrying nearly four thousand passengers and running at the rate of twelve miles an hour. The steam carriage that came nearest to success was that made in 1827 by Sir Goldsworthy Gurney. It is said to have made the journey from London to Bath and return, a distance of two hundred miles, at a speed of fifteen miles an hour. By 1831 several of Gurney's steam coaches were being used for regular service on roads.



A road engine invented by Richard Trevithick.

But the promoters of this new mode of transportation met with great opposition. The owners of horse coaches determined that the newfangled vehicles, which they feared would put them out of business, should not succeed. In 1865 they succeeded in having Parliament pass a law saying that no power vehicle could be used on a highway unless it was preceded by a man on horseback carrying a red flag to warn people. This put an end to the steam coach in England.



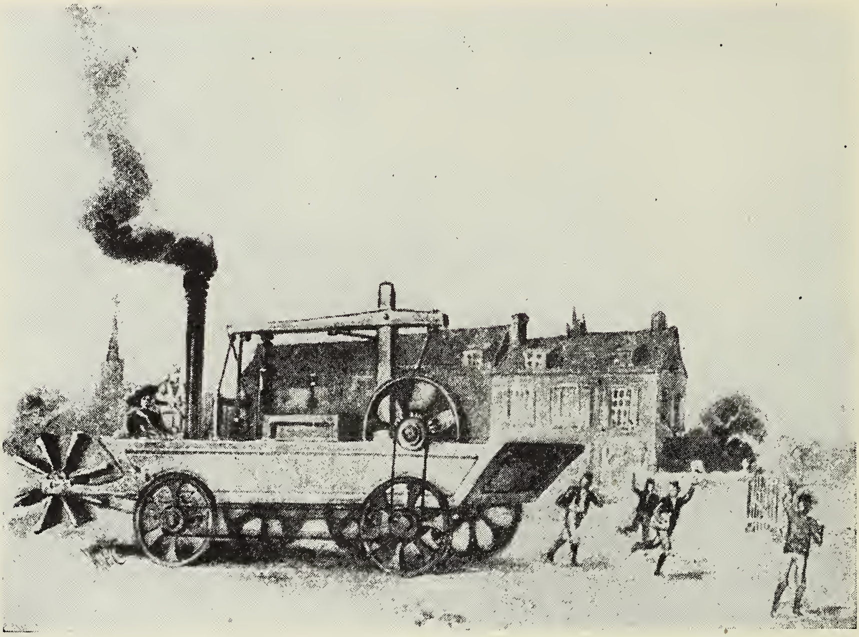
Gurney's steam coach, which ran in England in the early part of the nineteenth century.

American inventors also tried to develop vehicles driven by steam. As early as 1804 Oliver Evans of Philadelphia dreamed of using steam for propelling vehicles on roads. He had made a curious engine and set it in a flat-bottomed boat which was to be used for dredging the Philadelphia docks, and he decided that his engine could move it on land as well as in the water. So when the boat was finished he mounted it on wheels and propelled it by means of the engine to the Schuylkill River. Horses reared frantically in terror as this strange contraption puffed and clattered through the quiet streets of Philadelphia. The city fathers were indignant and warned Oliver Evans that any further use of it on the streets would be severely punished.

Church's steam carriage.

When the machine reached the banks of the river Oliver Evans removed the land wheels and, after launching the boat, used the paddle wheels attached to the stern. To the astonishment of everyone it kept on going in the water. Evans named this strange land-and-water vehicle the *Oruktor Amphibolos.*

The steam engine, however, with its big boiler and the large supply of fuel it required was found to be too heavy and clumsy for use on roads. A lighter and less cumbersome engine was needed. After petroleum was discovered and men learned how to make gasoline from it, it was found that gasoline when heated expands rapidly and becomes a vapor. Inventors found that by exploding this vapor inside a cylinder,



The *Oruktor Amphibolus,* built by Oliver Evans in Philadelphia in 1804.

by means of electric sparks, power could be made which would drive a piston just as expanding steam provides power to move the piston of a steam engine.

In 1884 Gottlieb Daimler, a German inventor, made a gasoline engine which produced a great deal of power. The gasoline engine is much lighter than the steam engine and the gasoline needed to run it requires much less space than the coal and water necessary for a steam engine.

After the invention of a successful gasoline engine strange-looking horseless carriages, as they were called, began to appear in some parts of this country. Just as the first railway coaches were stagecoaches, the first automobiles were buggies run by gasoline engines. Most people made fun of these early vehicles. With a clattering noise and a cloud of bad-smelling smoke pouring out of the back, a horseless carriage would come along. Often it would break down and someone from behind a tree would call out, "Get a horse!"

At first only a few automobiles were made. They cost so much that none but the rich could afford to have them. Then came Henry Ford, who saw in the automobile something more than a vehicle for rich people. More than any other one person he put motor transportation within reach of people of average means.

Henry Ford was born and brought up on a farm in Michigan. As a boy he drove the cows in to be milked, he kept the kitchen wood box filled, he harnessed the horses, and did the many chores about the farm. Best of all he liked the blacksmith shop. When his father or one of the farm men lighted the charcoal in the forge, Henry pulled the bellows till the fire glowed and the iron burning in it was white-hot. Fascinated, he watched the sparks fly from the anvil as the great hammer clanged on the metal shaping it.

Henry was much interested in steam. He watched the steam coming from the spout of the teakettle and wondered what would happen if steam were shut up so that it could not get out. One day he decided to find out. He filled a thick earthenware teapot with water, stuffed up the spout, tied down the lid, and put the teapot on the fire in the dining-room fireplace. Then he sat down to await results. After a little while Henry's mother, who was in the kitchen, was startled by the sound of a loud explosion. Henry's cry of pain brought her hurrying into the dining room. All about the room were scattered fragments of the teapot. One piece had cracked a mirror, another had broken a window, and a third had made a great gash on the youthful experimenter's face. Fortunately Henry was not badly hurt; but he had learned by experience what great power there is in steam.

One day Henry was driving to town with his father and at a turn in the road there suddenly appeared a road vehicle moving under its own power. In an instant Henry was off his father's wagon and talking with the driver about his strange-looking machine, asking him a dozen questions. How was it made, where was it going, and what was it used for? The driver explained that it was an engine for driving threshing machines and sawmills. It was equipped with a chain that connected the power with the rear wheels so that it could travel under its own steam.

Henry's father wanted him to be a farmer; but Henry did not like farm work. He was always thinking about machinery. When he was sixteen years old he decided that he was wasting his time on the farm. So he walked to Detroit, nine miles away, and got a job in a machine shop. Later his father asked him to return to the farm and he went back; but he continued to think about engines and machinery. On the farm he had a shop, where he experimented. He believed that much of the backbreaking work of the farm could be done by machines and he tried to make a "farm locomotive," as he called it; but he was not able to produce enough power to make it work successfully.

Henry's father laughed at his son's ideas and tried to steer him away from them. He gave Henry a large piece of land for a farm of his own and Henry married. He made his farm pay, but he still continued to work in his shop. In the evening he pored over mechanics' journals, following all the latest developments in engines. One night he read an account of a new kind of engine run by gas. Thus began his interest in the gasoline engine.

In a few years Henry rented his farm and returned to Detroit, where he went to work in the Edison Electric Lighting and Power Company. He was happy because his new job gave him a chance to work with machinery. After spending twelve hours a day in the Edison plant he hastened home and worked half the night in a little brick shed behind his house. By this time he had become interested in making a mechanically run carriage.

For four years Henry worked on his horseless carriage and at last it was finished. It was a rough affair—just a buggy frame, fitted with a two-cylinder engine and mounted on bicycle wheels with rubber tires.

It was two o'clock on an April morning, in 1893, when

Henry Ford finished his gasoline buggy. All his wife's efforts to drag him away from his work earlier had been in vain. The machine was ready for a trial. He opened wide the shed doors and pushed the car into the yard. He stepped into it and sat down carefully. He turned over the motor. It sputtered and hiccoughed, then settled down into a steady putt-putt. It was running!

The car wobbled unsteadily. Perched on the rough board seat Ford struggled desperately to steer it so that it would go straight. Rain was falling fast and it was very dark. Out of the yard and down the street chug-chugged the little car, zig-zagging from one side of the street to the other.

After traveling a few blocks the inventor decided to return. Could he turn? He could not. He stopped, jumped out, pulled and tugged until he had swung the rear end of the car around, and headed for home. Safely back in the yard again, the happy inventor pushed the machine into the shed and went into the house. He drank a glass of milk, spread his dripping clothes before the fire to dry, and went to bed. And all that day he slept. His four years of work had ended in success. He had built an automobile.

Ford's gasoline buggy was for sometime the only automobile in Detroit. His queer-looking contraption was considered rather a nuisance because it made such a racket, as it lurched through the streets, that it frightened horses.

For several years Ford continued to work twelve hours a day to earn a living for himself, his wife, and his little son, and then spent half the night improving his car. He wanted to go into the making of automobiles as a business and tried to raise capital; but no one would risk money in the venture. In

1899, however, he succeeded in building a small factory near Detroit. Other men became interested and the Detroit Automobile Company was formed. Ford's partners wanted him to build high-priced cars, but his idea was to build low-priced cars so that people of small means could afford to have them. So Ford gave up his partners and in 1903 formed the Ford Motor Company to develop his business in his own way.

All the money Ford made he put back into the business. "Money doesn't do me any good," he said. "I can't spend it on myself. Money has no value, anyway. It is merely a transmitter, like electricity. I try to keep it moving as fast as I can, for the best interests of everyone concerned. A man can't afford to look out for himself at the expense of anyone else, because anything that hurts the other man is bound to hurt him in the end."

When Ford first began making automobiles every car was built singly. Ford saw that much time would be saved if the parts were made separately in quantity and then put together to make the finished automobile. He organized his factory so that the work could be done in this way. By this method automobiles could be made quickly in large numbers and the selling price of the car could be made so low that almost every family could have one. Sales increased by leaps and bounds and the small profit on each car mounted to a large total. Thus Henry Ford built up a big business.

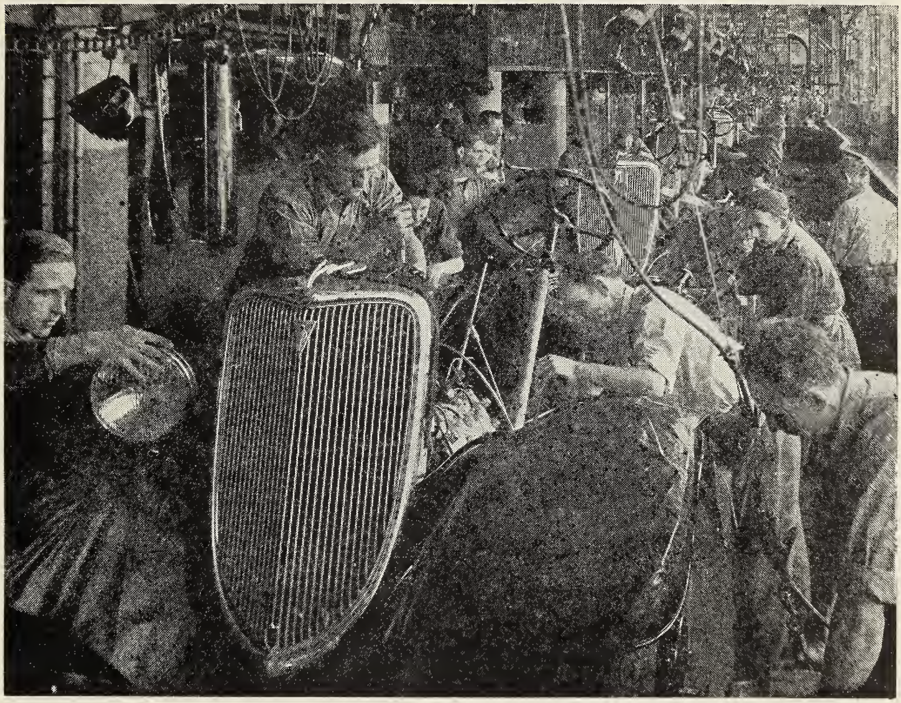
In and near Detroit, today, there are more than fifty automobile factories. From this city come every year more than half the automobiles built in the world.

In the automobile factory the principle followed is to have the work go to the workman rather than have the man go to the work. Everywhere in the plant the parts of the automobile are moved by conveyors of some sort to workmen stationed at various places. After the different parts are made they are placed along what is called the assembly line. The bare frame of a car is placed on a moving conveyor. As it slowly moves along, a man puts in the springs. Another drops the engine into place. At another point the wheels are attached. Farther down the line the cushions and fittings are put in. Thus, bit by bit, the automobile is built up.

In the tank of each car, as it comes to the end of the assembly line, is a gallon of gasoline. A worker slips into the driver's seat, steps on the starter, and the new car rolls off the line under its own power, followed by another, and another, and another, at the rate of one every two minutes.

The automobile would not have been a success without rubber tires, which are necessary to absorb the shocks of the road so that the car will ride smoothly. Goodyear, you remember, by his process of vulcanization, made it possible to use rubber. In the early days of the automobile smart carriages were being driven along the streets with solid-rubber tires. The earliest automobiles also used solid-rubber tires, but it was found that people could not travel very fast with comfort in cars with solid tires. In even the best roads there were uneven places that kept squeezing the tires out of shape.

An improvement came with the use of hollow rubber tires inflated with air. These were first used on automobiles by Michelin and Company, a firm of French rubber manufacturers. Michelin tried to induce French manufacturers of automobiles to use such tires, but found it impossible to interest anyone in the idea. To run a car on cushions of air was impossible, they said. So Michelin built a car equipped with air-filled tires and finally was able to convince automobile manufacturers of the advantage of using these tires. Since that time tires have been steadily improved.



Courtesy Ford Motor Company

Automobiles on the assembly line at the Ford Motor Works.

Motoring in the early days of the automobile was a real adventure. Except for important highways there were few hard-surfaced roads and as there were no windshields to protect people, the dust from the roads blew over them. Motorists had to wear dust coats to protect their clothes and goggles to protect their eyes. Men wore caps, and ladies tied their hats on with heavy veils.

Beginning with 1900 the automobile ceased to be merely a carriage with an engine instead of a horse to make it go, and came to be a real automobile. Windshields, self-starters, and many other devices were added to improve it. The one-cylinder engine gave way to those of two, four, six, eight, and even twelve cylinders. Today city streets and country roads are crowded with automobiles of many makes and styles. There are small cars and large cars and medium-sized cars. There are cheap cars and moderate-priced cars, and some that are very expensive.

The way people live has been greatly changed by the automobile. It is so easy to go long distances in an automobile that there is much more traveling today than there was before the automobile came into use. Farmers can now enjoy the pleasures of the city, and city dwellers can drive out into the country for recreation. Businessmen living on the outskirts of cities can drive in and out in the morning and evening, and thus enjoy the advantages of country or suburban towns.

For the people who do not own automobiles there is another convenient way of going from place to place—the motorbus. There are bus lines in almost all large cities and lines running from one city to another. These busses are large, luxurious affairs. They leave on schedule time, go at a good rate of speed, and are safe and economical. Today many thousands of motor busses are in daily service over the nation's highways.

In 1905 the motor truck began to be used as a means of transportation. Today great fleets of motor trucks haul produce to our larger cities. Other trucks deliver goods to our stores and our homes. Some are built like refrigerators, which make it possible to send perishable products long distances. Butter, eggs, fruit, and vegetables arrive in the city markets from farms miles away as fresh as when they left the farms.

Automobiles have brought good roads. In the early days of the automobile, most roads were narrow dirt roads deeply rutted by wagons. The automobile could not travel quickly over such poor, rough roads. Good, smooth roads were a necessity. Today splendid highway systems link all parts of the country in a great concrete network that makes automobile travel quick and comfortable.

CHAPTER XX

Sending Messages without Wires

WONDERFUL as were the telegraph, the cable, and the telephone, much remained to be accomplished before perfect communication could be achieved, for where wires could not be strung communication was still impossible. Inventors began to dream of sending messages without wires.

Scientists tell us that everywhere about us is an invisible sea of ether. It pervades everything and penetrates all things, even the most solid substances. The energy of the sun's rays, passing through the ether, creates waves, just as water carries wave motions on its surface.

If you throw a stone into a pond it starts ripples, or waves, that go on and on in ever-widening circles, until they reach the shore of the pond or until their force is spent. One day, in 1887, Heinrich Hertz, a young German scientist, discovered, by accident, that a spark of electricity would cause the ether waves to radiate in a similar way.

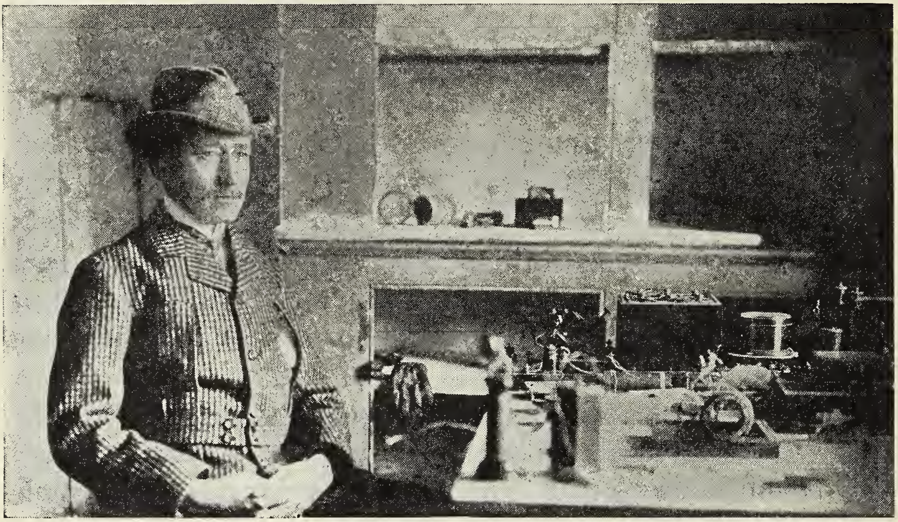
Hertz was experimenting in his laboratory with two coils of wire, one of which had a short gap in it. He passed electricity through the coil and, to his surprise, with a flash and a crackle, the current jumped the gap. Then the second coil of wire, lying near by, received the current of electricity sent out by the first coil. Later Hertz found that the current would leap across space even when the wires were widely separated. After many experiments he invented a machine by which the waves might be caught as they traveled through space. He published the results of his experiments and the scientific world honored him by giving his discovery the name of Hertzian waves.

Hertz died in 1894, and other scientists carried on the work that he left unfinished. By many, the Hertzian waves were thought to be just another scientific curiosity. That they could have a practical application to the needs of a busy world few people saw. But men of inventive minds began working on the problem of making those magic waves bear messages. It was left for an Italian youth, Guglielmo Marconi, to gather together the discoveries of several others and bring them to final success.

Electricity had been Marconi's hobby from the time he was twelve years old. When he grew older he went to a university and studied about it with a noted professor. An article in an electrical journal on the Hertzian waves suggested to young Marconi that these waves might furnish mankind with a new and powerful means of communication.

This started the youthful inventor on a series of experiments. Marconi's father encouraged him and gave him the garden to experiment in. On a pole at one side of the garden he rigged up a tin box, to which he connected his homemade transmitting apparatus. At the other side of the garden he set up another pole with a tin box as a receiving apparatus for the first test. By turning on and shutting off a current of electricity by means of a device similar to the telegrapher's key, the electromagnetic waves could be divided to make dots and dashes and spell out the letters of the Morse alphabet.

Much time was spent in planning and making the apparatus for the first test. Finally everything was ready. Suddenly the Morse sounder began to tick. What did this mean? It meant that the electrical waves had passed through the space where there was no wire. Marconi's heart gave an exultant bound.



Courtesy Marconi's Wireless Telegraph Company, London

Marconi in Newfoundland in 1901, with the instruments with which he received the first wireless message across the Atlantic.

One day while he was experimenting, Marconi noticed that an instrument on the opposite side of a hill from the sending apparatus was affected. The only way that this instrument could be affected was by the electric waves passing through the hill.

"If electric waves will pass through a hill, they can be made to pass long distances over the land and even over the ocean, and it will be possible to telegraph without wires," said Marconi to himself.

The quiet Italian villa was the scene of many other experiments. Steadily Marconi pushed ahead, succeeding in reaching more and more distant points. After two years of experimenting he had so far improved his apparatus that he was sending signals over a distance of several miles.

Marconi decided that it was time to introduce his invention to the world. Finding no one in Italy ready to take up his idea, he went to England to develop his invention there. By 1899 he had made such improvements in his instruments that he was able to send wireless messages across the English Channel, a distance of twenty-eight miles. Then he dreamed of the greatest goal of all—sending messages without wires across the broad Atlantic.

Many scientists believed that the electromagnetic waves would not follow the earth's curve for such a distance. They thought that they would go off into space. Was that true? The only way to find out was to experiment and see.

In the winter of 1901 a powerful sending station was erected in Cornwall, the western tip of England, for the great test. Very quietly Marconi took a ship for America. Only a few people knew what he was trying to do. The place he had chosen for receiving the messages was the coast of Newfoundland, the nearest point in a straight line to England. There he set up his receiving apparatus.

On December 12, 1901, everything was in readiness for the great trans-Atlantic experiment. Before leaving England

Marconi had made arrangements to have signals sent to him at a certain time that day. It had been decided that three dots, the Morse code representing the letter S, should be used as a signal.

Young Marconi and his assistant sat at a little table in a bare little room of an old shack. Near the inventor was his receiving instrument, connected with a wire which ran out of the window to a gigantic kite flying four hundred feet overhead. It was a raw, bleak day, and the wind was tossing the big kite wildly. Two thousand miles away, on the west coast of England, sat an operator at the foot of a mast more than two hundred feet high, with a wire hanging down from it which was connected with the sending apparatus.

The time for the signals drew near. Scarcely daring to hope, Marconi sat holding a telephone receiver to his ear, listening intently. A long time passed and not a sound broke the intense silence. Would he be unable to hear the signals over the long ocean miles? For six years he had been looking forward to this moment. Was he to fail?

Then—what was that? Marconi thought he heard a faint tick. He listened again. Faintly, almost too faintly to be heard, something was coming. Yes, click, click, click, came the signal he had arranged for, the three dots representing the letter S of the Morse code.

Marconi wanted to be sure. Handing the receiver to his assistant, he said quietly, "See if you can hear anything, Mr. Kemp."

Kemp seized the receiver and listened. All was quiet again. But in a few moments Kemp joyfully replied that he could hear very distinctly three little clicks. Marconi listened again.

More signals came. There could be no doubt. The sound had leaped two thousand miles across the ocean. The work of long years was rewarded and Marconi's dream had come true. Here was an instantaneous means of communication which could not be stopped by distance, by mountains, or bodies of water.

"The experience gained by these tests," said Marconi afterward, "was sufficient to convince me and my assistants that, with permanent stations on both sides of the Atlantic and by the employment of greater power, messages could be sent across the ocean with the same facility as had been done up to then over much shorter distances."

The next day the news was flashed all over the world that for the first time in history messages had been sent across the Atlantic without wires. But it was not believed. People scoffed at the idea of talking through space; they thought that Marconi had been mistaken in thinking he had received messages.

Marconi made a plan to prove to the doubters that he was not mistaken. He went back to England, where he again took passage on the liner *Philadelphia,* bound for America. He rigged up a receiver on the ship. Before sailing he had given instructions to his assistant in England to send signals at certain stated times during the week of the voyage. After a few days aboard ship he began receiving messages.

Marsden, the chief officer of the *Philadelphia,* happened to be in the room when the first message was ticked out. It was astounding beyond belief. He could scarcely trust his senses. Excitedly he rushed around the ship, telling his fellow officers about the new marvel.

"Ha! Ha!" they laughed. "Do you expect us to believe that?"

"Wait until tomorrow, then, and see for yourselves," replied Marsden.

The next day the officers crowded into Marconi's cabin. Watch in hand, Marconi sat looking at his instrument. The time for receiving the message had arrived. Tap! Tap! Tap! sounded the receiving instrument as it clicked against a piece of tape.

"There it comes!" exclaimed Marconi, looking up with a little smile at the circle of amazed faces.

Tap! Tap! Tap! clicked the metallic finger again as it recorded what the invisible waves were saying. Another message waved its way through the ether and was received a thousand miles out at sea. The next day more messages came, and the day following, and the day after that.

"Will they say now that I was mistaken in Newfoundland?" Marconi asked, as he pointed to the narrow piece of tape covered with messages.

The world could no longer doubt. There was the proof.

Even after this, however, no one paid much attention to the invention, although Marconi did succeed in getting his instruments placed on some of the larger ocean liners. Then, in 1909, the value of wireless was fully proved.

Up to that time a ship, when it left port, was cut off from the rest of the world until it reached another harbor. If there was a disaster at sea, the captain and crew had only signal flags, rockets, flares, or perhaps a gun, with which to call for help, and if no vessels happened to be within sight or sound, all on board might perish.

On the night of January 22, 1909, the big White Star Liner *Republic,* outward bound from New York, was moving slowly through a thick fog. Coming from the southeast was the *Florida,* bound for New York. The two ships were approaching each other with only their whistles to guide them.

When Captain Sealby of the *Republic,* judging by the sound of the *Florida's* whistle, thought that the other boat was too near, he sounded two short blasts of his whistle. This is the signal to the captain of an approaching vessel to "port his helm," also signifying that the ship signaling will do the same. Thus each ship will turn away from the other and they will pass in safety.

But something went wrong, and with a terrific crash the bow of the *Florida* struck the *Republic* amidships, ripping a great hole in her side. Then the *Florida* slid backward and was swallowed up by the fog. Tons of water poured into the hold of the *Republic* and the ship began to sink.

Fortunately the *Republic* was equipped with wireless. Up in a wireless room Jack Binns, the operator, began frantically tapping out the signal CQD, which was the call for help in those days. And through the blackness of the night flashed over the magic ether waves the message: "We were struck by an unknown boat; engine room filled; passengers all safe; can stay afloat; Latitude 40:17, Longitude 70. *Republic.*"

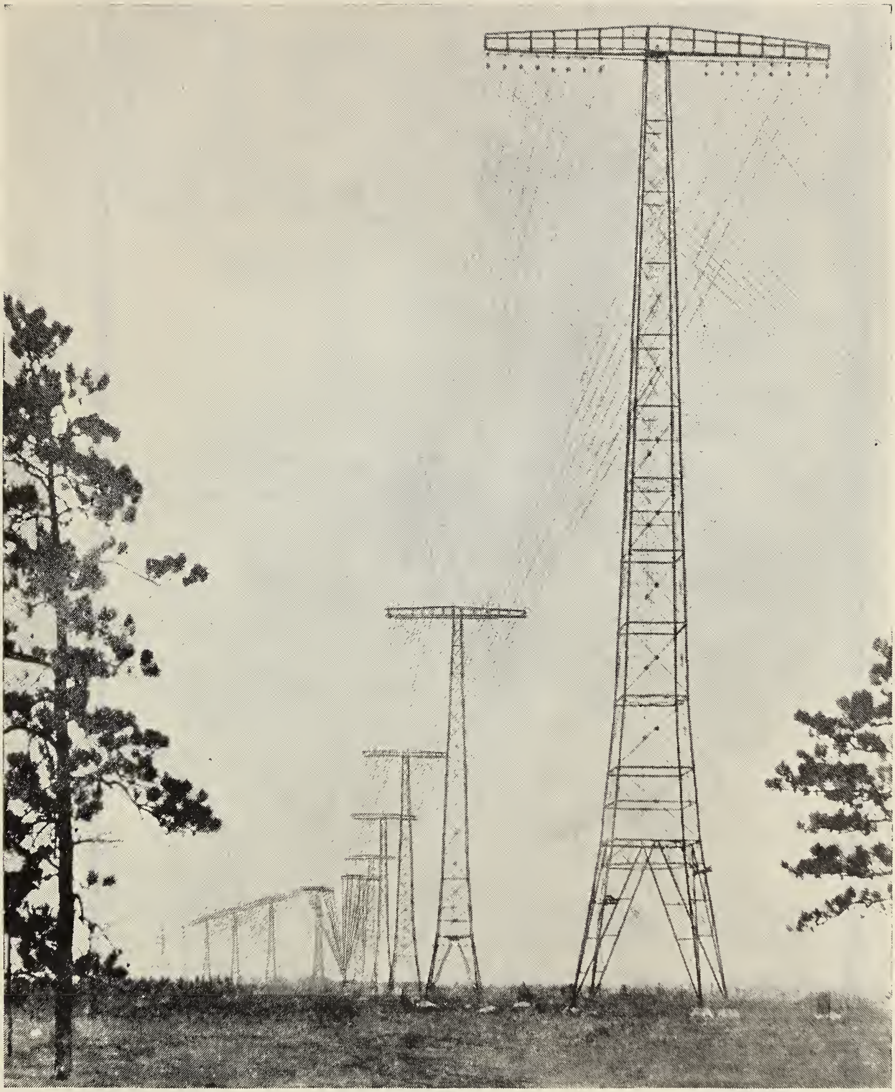
Instantly the message was caught by other ships equipped with wireless and they responded to the call of the stricken *Republic.* At last the *Baltic* reached the sinking ship and took off all her passengers and crew, as well as those of the *Florida.*

The world suddenly realized that a wonderful new invention had come to the aid of ships at sea. Wireless stations were built along the coasts of Europe and America, and messages began to flash back and forth between the two continents. Since that time the Marconi system of wireless has been adopted by all civilized countries.

But even wireless was not to be the final word in the development of communication. It was not long after Marconi's invention before scientists were working on the problem of sending the actual sounds of the voice over the air, instead of merely transmitting code messages, as is done with wireless. Fifteen years after the first wireless message was sent, radio began its matchless conquest of space. The invention of the radio was accomplished not by any one man, but by a number of inventors, each of whom added something.

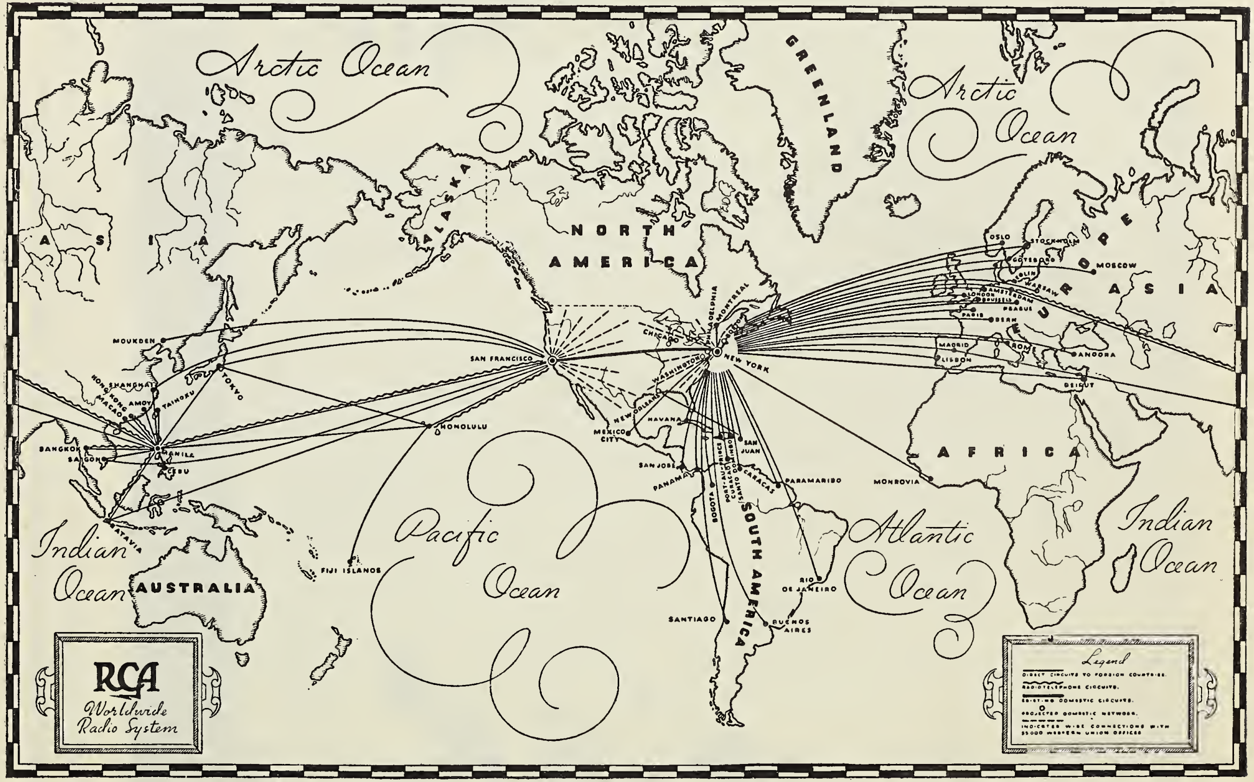
Today the whole world seems to be within our reach merely with the turn of a dial. The farmer, sitting at home after his day's work, can hear the latest news. Explorers, encamped in snowbound wastes, thousands of miles from the nearest settled community, are in touch with centers of civilization. People on ships or in trains can at any moment communicate with other people far distant from them. The pilots of planes can now fly through fog or darkness, while they talk with ground stations and receive weather reports and flying instructions, and the radio beam guides many a plane to a safe landing. Lost persons are often found by aid of a radio appeal, and many lives have been saved by a radio call for a doctor or for medicine.

Thus, every day, radio proves its importance in our lives. In olden days ideas traveled slowly; now they go around the earth in an instant. So, through the work of scientists and in-



Courtesy Radio Corporation of America

High-powered transmitters at Rocky Point, Long Island, which maintain radio communication with Europe, Asia, and South America.



Courtesy Radio Corporation of America

Today all the countries of the world are connected by radio.

ventors, man has been able to overcome the vast barriers of space. Through the magic of the ether waves the different parts of the world have been united into one great community, every part of which is in touch with every other part.

CHAPTER XXI

Man Learns to Fly

THE steamboat improved water travel, the locomotive and the automobile speeded up transportation on land, and last of all the improvements in transportation has come travel by air.

All through the ages, from his very earliest days on earth, one of man's greatest desires has been to fly through the air; but for many centuries the idea of flying remained only a dream. Then man began fastening artificial wings on his arms and legs and jumping off high places, attempting to imitate the birds in flying. This method of traveling through the air was not very successful.

Giving up for a time the idea of wings, men found that they could make ascents into the air in a basket attached to a big bag filled with hot air, or with hydrogen gas. These were the first balloons. Many thrilling trips were made in them.

Up to the middle of the nineteenth century balloons were without any power for moving them. They were merely floating bags, at the mercy of the air currents for movement. If the wind blew west, the balloon sailed west; if the wind blew east, the balloon sailed east. To make the balloon practically useful some way must be found to steer it. Many ideas were tried out. Some men attempted to steer balloons with oars;

others tried using sails; still others used paddle wheels. But none of these schemes was successful.

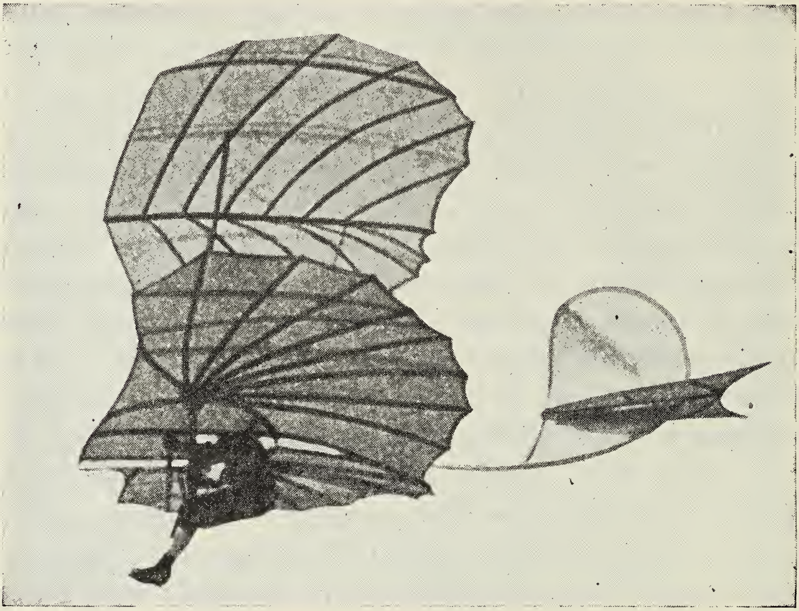
By 1850 steam engines were being used to propel locomotives on the land and boats on the water. Why not use a steam engine to drive a balloon through the air? In 1852 Henri Giffard, a French engineer, designed and built a power-driven balloon. In the long car which was hung under the balloon was placed a small steam engine which Giffard had made especially for his airship. This marked the beginning of the development of engine-driven airships, or dirigibles.

Dirigibles were improved very slowly because of the lack of a light, powerful engine. No sooner was the gas engine made practicable and applied to automobiles than inventors used it in airships. In Germany improvements were made in airships by Count Ferdinand von Zeppelin. Instead of making one round collapsible cloth bag, like those of the old balloons, he built a long, pencil-shaped bag with a rigid aluminum frame to hold the separate bags of gas. Airships constructed with these metal frames were stronger and safer. Zeppelin's huge airships soon surpassed all others and became more and more serviceable in long-distance flights.

In the meantime, man had not given up his efforts to fly with wings. Instead of flapping these wings, he began encompassing himself with a framework of semirigid wings and tail. Thus the glider was born. With the glider, man found that he was able to remain in the air for an unbelievably long time, and travel many miles.

One of the most famous of the experimenters with the glider was a young German by the name of Otto Lilienthal. For years he built and flew kites of various shapes. Then he built a glider with a pair of wings and a tail for balancing. The wings were fastened to each side of his body and were controlled by his arms.

There were sand hills near Lilienthal's home and on them he made many flights in his glider. When the wind was right he would run down the side of the hill until he gained good speed, then he would give a jump, draw up his legs, and glide through the air. Lilienthal developed great skill in using his body to maintain his balance. As the wind caught the surface of the glider he would turn and twist, shifting his weight to counteract the effect of the wind.



Otto Lilienthal in one of his gliders.

Lilienthal built many gliders. With each new machine he gained more control in flight. For years he experimented, constantly discovering new facts about the winds, constantly improving his gliders, and succeeding in making longer and longer flights. But one day, when he was testing a steering device on a new glider, he lost control, crashed to the ground, and was killed.

At the time of Lilienthal's death two boys, Orville and Wilbur Wright, were growing up in Dayton, Ohio. One day as the boys were playing in their home, the door opened and their father entered with quite a mysterious air. In his hands he was hiding something. What could it be? Before they could see what it was he opened his hands and, with a whir, an odd-looking object leaped into the air, and flew up until it struck the ceiling. There it fluttered for a time, then it slowly settled toward the floor.

"Oh-h-h!" cried the boys, and pounced upon it. They found that the flying toy was a light, flimsy little thing made of bamboo and paper, with two wings which were moved by twisted rubber bands. Their father explained that it was called a helicopter; but the boys called it "the bat."

Wilbur and Orville flew the bat indoors and out. The delicately made little toy could not long survive the hard use to which it was put. Soon it began coming apart. The boys patched the rents in the paper, repaired the breaks in the bamboo, and continued to play with the bat until there was no bat left.

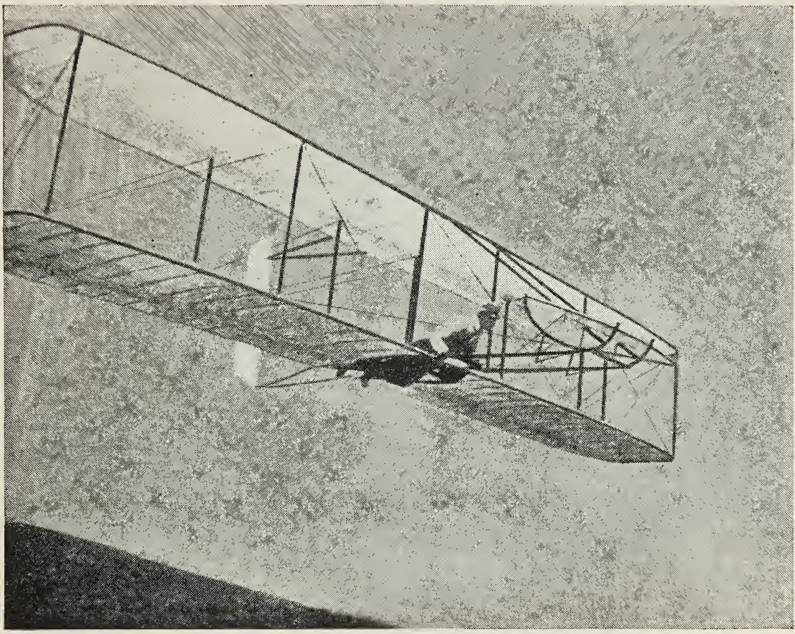
When the bat's short life was ended the brothers decided to make another one. They gathered strips of bamboo, sheets of heavy paper, and bits of cork and light wood. They whittled and cut, measured and figured. At length they were ready to try out their first flying machine. To their delight they found that it would fly. Later came the kite fever and the boys became experts in making and flying kites.

Thus Orville and Wilbur Wright, who were to give the world the first successful airplane, had their first experiences with flying machines when they were boys.

Wilbur Wright was a great reader. One day he read Orville an account in a newspaper of the work of Otto Lilienthal. The boys were fascinated with the idea of riding through the air. They read all Lilienthal's writings and everything else they could find in the public library on the subject of flying. They became interested in birds and for months spent all their spare time studying the ways in which these living flying machines balance themselves on currents of air. They experimented with air currents. They let pieces of paper flutter through the air, noting how the pieces of paper, caught up by the currents of air, twisted and twirled and turned. They took small pieces of cardboard and bent and cut them in various ways. They balanced these in front of streams of air blown through a blowpipe, and observed what happened to them. Through all these experiments the boys were learning the ways of the air.

When they were grown the Wrights began to build a glider. They decided that maintaining balance by shifting the body at every gust of wind, as Lilienthal had done, was too difficult and exhausting. They realized that a completely controllable machine would never come until some method of mechanically balancing the wings had been found. The young inventors worked out a method of warping the wings of their glider to preserve its balance. They also put a rudder in front. Thus they were able to control their machine.

Another new idea was the position of the operator of the glider. Lilienthal and other users of gliders had all ridden in an upright position, with the entire surface of their bodies exposed to the wind. The Wrights saw that if the operator lay flat on the lower wing only a small surface of the body would be presented to the wind, and thus the wind resistance would be reduced.



Wilbur Wright in his glider at Kitty Hawk, North Carolina.

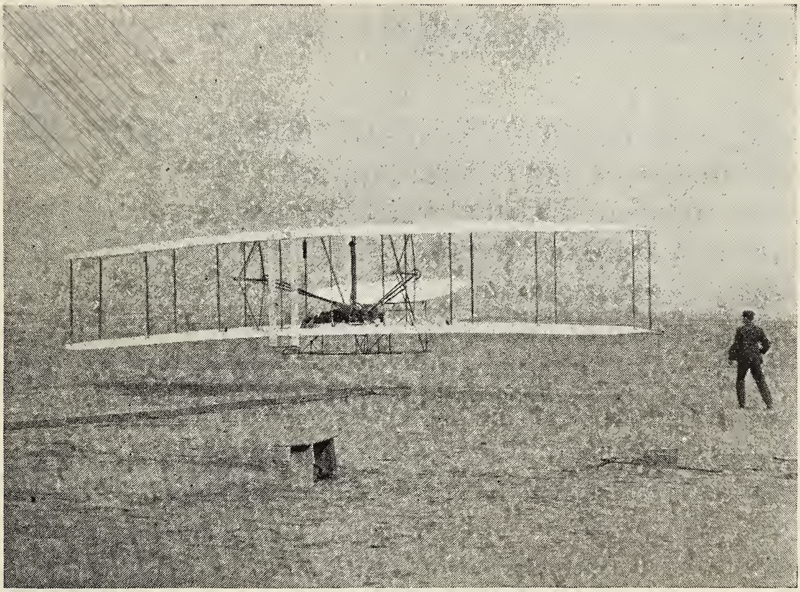
The experimenters wanted to try out their new ideas in a place where they would have the right kind of wind. From the United States Weather Bureau they learned that at Kitty Hawk, on the coast of North Carolina, the wind blew smoothly and steadily. In this wild region, one of the loneliest places in the country, there were high sand dunes which offered good opportunity for gliding and soft places on which to alight if they should fall. There, in 1900, they pitched their camp and built a glider.

By early October the glider was ready for its first trial. Would the machine, on which they had spent so much time and thought, stand the trial to which they were about to put it? They believed that it would.

One of the brothers took his position in the glider, lying down on the lower wing, his hands gripping the handles in which the two sets of control wires ended. The other brother loosened the ropes which held the glider to the ground, and gave the machine a push to start it. Slowly the glider with its human burden left the earth and soared into the air. There was great rejoicing. Again and again the machine was launched. Each time it stayed in the air a little longer. The test had convinced the Wrights that mechanical flight was possible. It was time to return to Dayton.

For three years the brothers continued experimenting in an old bicycle shop in Dayton. The middle of the shop was cleared to make space for a device called a wind tunnel. This was a square tube six feet long. One end was open; at the other was a machine that could be made to whirl a fan at high speed, sending a current of air through the tube. With little models the effect of air pressure was tested.

During this time the idea of making a power machine—one that would fly regardless of wind, and descend wherever they wanted it to—came to the Wrights. There were two new problems. One was the motor, the other was the propeller.



Orville Wright flying at Kitty Hawk, North Carolina, December 17, 1903. Wilbur Wright is running alongside the machine. This was the first flight in a heavier-than-air motor-driven plane.

They built a small four-cylinder engine and they worked for months fashioning a propeller. At last came the day when they hitched a finished propeller to the motor and started it to work.

By December, 1903, the Wrights were ready for their first attempt to fly in their motor-propelled machine. They were back at Kitty Hawk again. Everything was ready. The motor had been tested and found to be in perfect condition. The wind was mild. Who was to be the first to fly? The brothers tossed a coin to see, and Wilbur won. He climbed onto the lower wing of the plane, stretched out flat and lay face down. The motor clattered and roared. Wilbur released the catch by which the restraining wire was held, and with a rush the big boxlike affair darted forward so quickly that Orville, running beside it, was left behind in an instant. It lifted into the air and climbed upward. Then it came down. Orville snapped the stop watch he held in his hand. It registered a flight of three and a half seconds.

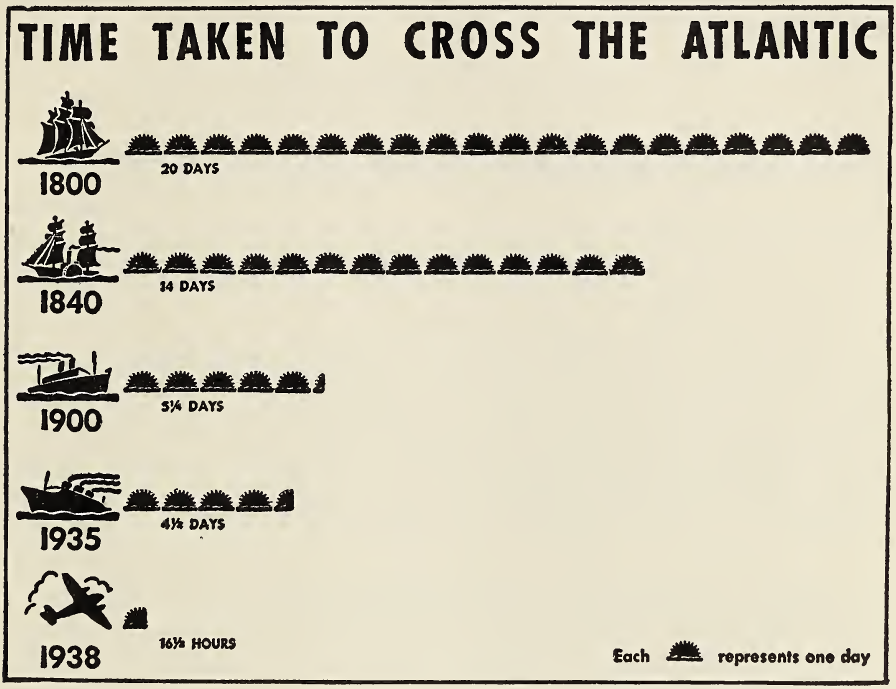
This was the beginning. Before the close of that eventful day a flight lasting fifty-eight seconds had been made—almost a minute. For the first time in the history of the world a heavier-than-air machine had raised itself from the ground and made its way in the air by its own power.

The agelong dream of man had at last come true. Man had learned to fly.

After their first successful flights the Wrights continued their experiments. By 1904 they had succeeded in flying for five minutes; by 1908 they were able to stay aloft an hour. Thus Wilbur and Orville Wright solved the problem of the heavier-than-air machine and gave the world the modern airplane.

From that time on, progress in aviation was rapid. During the World War both airplanes and airships came into use. Every nation involved in the war strove to gain an advantage over its adversaries by building faster, safer, and larger aircraft. The result was that aviation made greater progress during the four years of the war than it probably would have made in a much longer period of peace.

When the war was over, interest in aviation continued, and there began an era of heroic flights as intrepid airmen made their way across continents and oceans and around the globe, blazing the sky routes of the world. After these pioneers had done their work, commercial airplane lines were established. Airplanes now give regular service in every continent of the world and air travel is rapidly becoming a safe, swift, and comfortable means of transportation.



Courtesy Foreign Policy Association

Today steamships, railroads, automobiles, airplanes, and airships enable people to travel for business and pleasure by land, by water, and by air. If it were not for these wonderful modern methods of transportation we should still be living very much as people lived before the days of the Industrial Revolution.

CHAPTER XXII

Rich Man, Poor Man

THE industrial age has brought about a new organization of business. In the early days of the Industrial Revolution all business was carried on in a small way. There were little foundries, little mills, little businesses, each owned by an individual or by a small group of partners. By the middle of the nineteenth century many raw materials valuable to industry had been discovered, machinery had been invented to make them available, men were organized to turn out manufactured goods in great quantities; but it became apparent that large amounts of money were needed to develop the new industries on a big scale.

No one man, or even group of men, was wealthy enough to supply all the money needed for the rapidly expanding business of this time, so a new way of getting money was devised. A number of men combined to form a corporation. They issued stocks and bonds. Any person with money to invest could buy bonds or stock. These people became stockholders in the corporation, and received their share of the profits, called dividends, in proportion to the amount of stock or bonds they owned. When put all together, the small sums from many people provided businessmen with the large amounts of capital needed to develop their enterprises.

This was the time of the rise of the big businessmen. These men began their business careers just when our natural resources were being opened up. They developed industries from the newly discovered raw materials; they took over the new inventions, raised capital to finance them, and organized corporations. They searched out the four corners of the earth for markets in which to sell their goods. The men who built

An early shoemaker shop. The man at the left owns the shop and the others are his apprentices. Today, instead of one man with hand tools doing all the work of making a shoe, we have big factories with great machines and hundreds of workers, each of whom makes a small part of a shoe.

up these great business enterprises were the pioneers of the industrial age in which we are living today.

Several companies led in this new type of business organization. The first of these were the Standard Oil Company and the United States Steel Corporation. Let us trace very briefly their development.

In the early years of the nineteenth century John D. Rockefeller, a young lad of sixteen, tramped the streets of Cleveland, Ohio, seeking work; but no one needed a boy. At last, one day, a man told him that he might return after the noonday meal, and Rockefeller secured his first job.

Soon young Rockefeller became a bookkeeper. Perched on a high stool, he was busy from morning till night adding up long columns of figures. At first his salary was only twenty-five dollars a month, but somehow he managed to save something each month. Before he was twenty-five he had saved several thousand dollars. Then, in partnership with another man, he started a small business of his own.

When the discovery of oil was creating much excitement in Oil Creek, Pennsylvania, Rockefeller decided to go there to investigate. He was met at Titusville by a Mr. Breed and the two set out for the oil region. Oil flowed so freely over all this region that it frequently ran upon the surface of the ground. Almost at the end of their journey Breed and Rockefeller came to a gulley, over which a log had been thrown for people to cross.

Rockefeller looked at the log and said, "Isn't there some way we can go around this thing?"

"No, we will have to make it," said Mr. Breed, and led the way.

Safely across, Mr. Breed turned to help Rockefeller and was just in time to see him slip off the log into the oily ground in the gulley. Breed hauled him out, scraped from his suit as much of the ill-smelling oil as possible, and was for leaving; but Rockefeller said that since he had "dipped into the business" he wanted to see everything.

Rockefeller had to buy a new suit of clothes before he left Titusville, but evidently his trip impressed him favorably, for in 1858 he invested his savings in a small oil refinery. Later he organized an oil business of his own. His business thrived and by 1870 had developed into the Standard Oil Company.

Scores of little refineries had sprung up in the region between Pittsburgh and Cleveland. At first the profits were large and they flourished, but soon came overproduction and many refineries failed. The Standard Oil Company bought up at low rates many of the failing refineries and thus it grew bigger and bigger.

Competition between the various oil companies was keen. In the early days the barrels in which oil was transported were expensive. So the Standard Oil Company began making its own barrels, thereby saving the profit that had been made by the barrelmakers. Then it was able to sell its oil for less than other companies who did not make their barrels.

Steadily the business grew and related industries were brought under its control. In time the Standard Oil Company developed into the first big corporation in America, controlling most of the oil business in the country. When Rockefeller retired in 1884 he was the richest man in the world.

Another man living at the time of our great industrial growth was Andrew Carnegie, who built up his business into the world's largest corporation, the United States Steel Corporation. His story also is an interesting one.

Just at the beginning of the Industrial Revolution, when weaving was still being done on hand looms in people's houses, there was living in Scotland a weaver by the name of Carnegie, the father of Andrew Carnegie. He had four looms and several apprentices and was looked upon as a well-to-do man.

After Cartwright's power loom was invented, it became harder for the hand-loom weavers to get work. Andrew's father did not realize that the new way of making cloth was rapidly coming in and struggled along with his hand looms. But soon he found himself in a world in which he could no longer make a living. At last came a terrible day, when, after tramping the streets for hours, he returned home in despair and said to his little boy in his broad Scotch dialect, "Andra, I can get nae mair work."

As there seemed no future for Carnegie in his own country, the little family, like many others in Europe at that time, turned to the land of promise, America. Some relatives had settled in Pittsburgh and were doing well. The Carnegies decided to go there, too.

In Pittsburgh the father found work in a cotton mill. Young Andy became a bobbin boy in the same mill. Later Andrew Carnegie became a telegraph operator and Thomas Scott, an official of the Pennsylvania Railroad, selected him as operator for the railroad. Later Mr. Scott decided that Carnegie was just the kind of young man he wanted as his secretary. Carnegie did his work so well that when Mr. Scott was promoted Carnegie took his place as superintendent. Each promotion meant much to the hard-working young man.

At this time the railroads were becoming dangerous to travelers. The iron rails that were then used were not strong enough for the heavy trains that were coming into use and there were many accidents. On a trip to England Carnegie saw a Bessemer furnace in full blast. It seemed to him miraculous. He sensed the great value of steel to the railroads. He returned to Pittsburgh and organized the Edgar Thomson Steel Works to make steel by the new Bessemer process.

In the earlier days of the steel business it was customary for the ironmakers to smelt ore and sell the ore to the steel companies. Likewise, the steel company bought its coal from a coal company, and the other things it needed from other companies. Steamship companies and railroads had to be paid for hauling things. Each company added its profit to the cost of what it sold.

Little by little Carnegie's company took into their organization the companies on which they were dependent for raw materials, for fuel, and for transportation. They bought tracts of land containing iron and coal. They bought the railroads and steamship lines necessary to transport the coal and iron from the mines to the steel plant. In time they owned every part of the steel business from start to finish. When they owned every process and paid no profits to any other company they were able to sell their steel for less than that of companies which had to pay out these profits to other firms. So they got more and more business. Before long the United States Steel Company, as Carnegie's company came to be called, was doing most of the steel business in the United States.

Thus the United States Steel Corporation grew out of the little iron business started by Carnegie, and Andrew Carnegie, who began life as a little bobbin boy, grew to be one of the world's richest men.

What happened in the case of iron and steel happened with other raw materials. Businesses dealing in tobacco, sugar, and other important materials developed into great corporations.

A similar development took place with the railroads of the country. You remember that the early railroads were just short lines connecting important places. Each road belonged to a different company, and the tracks of the different companies were different widths. As the industries of the country developed, some farseeing businessmen realized the coming importance of the railroads. They began buying up short lines, combining them into railroad systems, and making the tracks all the same width so that trains could be run over long distances without changing passengers or freight.

One of the first men to do this was Cornelius Vanderbilt. Vanderbilt bought a number of short railroads and united them into the New York Central System. J. J. Hill and E. H. Harriman developed the great railroad systems of the West and Northwest. The years following saw lines extended swiftly to almost every part of the country.

The railroads needed capital. They formed corporations to get the necessary money. They needed quantities of steel for locomotives, rails, coaches, and so on, and they bought stock in steel companies. They needed large amounts of coal, and they purchased coal mines. So the railroad corporations grew in size and extent.

The railroad builders provided faster and more reliable transportation than had ever been known in the history of the world. They made the transportation of people and goods cheaper. They helped to make possible the development of many natural resources little known before the middle of the century. By providing a nationwide means of moving goods they made a great contribution to the development of the trade and industries of the country.

Before an invention can be widely used a business must be organized to manufacture it in large quantities. Businessmen organized companies, raised capital, and built up great business organizations for each of the most important inventions of the nineteenth century. Out of Bell's invention grew the American Telephone and Telegraph Company, from McCormick's reaper developed the International Harvester Company, out of Morse's invention came the Western Union Telegraph Company, and so on.

Thus the little enterprises of the early days of the nineteenth century grew into huge business organizations with capital of many millions of dollars. With the large amounts of capital at their disposal these business organizations can produce large amounts of goods at low cost and can therefore sell their products at a low price. It is because of mass production brought about by large business organizations that people of ordinary means are able to enjoy many comforts and conveniences which they would otherwise not be able to have.

We have seen how large fortunes were amassed by the leaders in various industries. What about the workers—the large number of people who did the actual work of mining the coal and iron, operating the steel furnaces, building the towering skyscrapers, keeping the whirring machines going—were they becoming prosperous, too?

You have read about the sad condition of the workers in the early days of the Industrial Revolution. At that time they could earn barely enough for miserable homes, insufficient food, and cheap clothing. Their children were working also and were receiving only the barest rudiments of an education.

The workers of that time found that they must accept whatever wages their employers were willing to pay, and work the number of hours their employers demanded. No longer could they raise their food and make their clothing as they had done in the days before the factory came. These necessities they had to buy with what they earned. And though every member of the family worked from dawn till dark they could earn barely enough to allow them a decent place to live. Most of the homes of the workers were poor tenements, often lacking in water and air.

If a factory was dark, poorly ventilated, and unhealthful, or if the hours were long and the wages low, what could a worker do? Nothing, for in other factories the conditions were just as bad and the worker had no other way of supporting himself and his family.

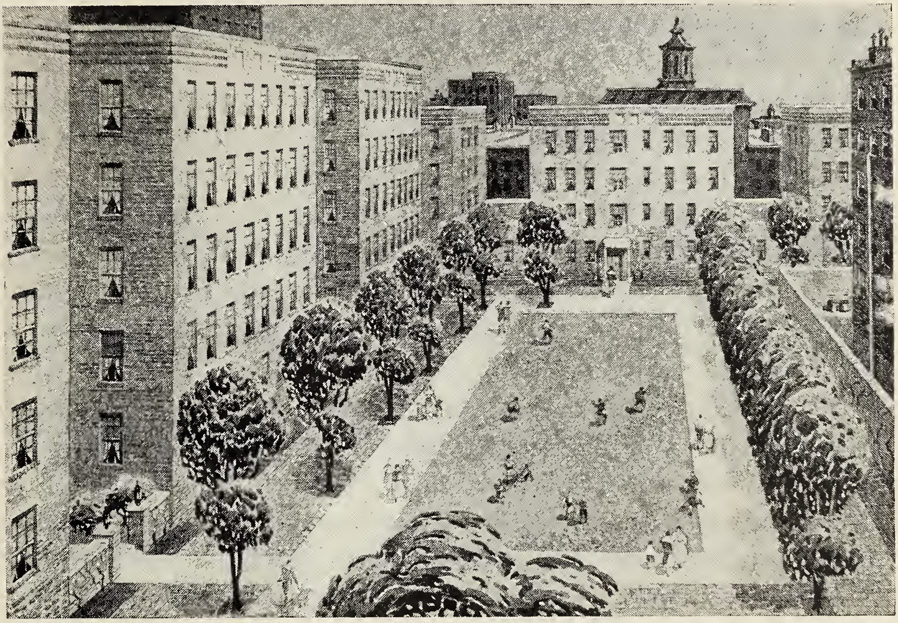
The lot of the laboring people was indeed hard. Their lives were one continuous grind from year to year with little chance for advancement. They came to see that although one worker alone could not secure better wages, shorter hours, and better conditions of work, many banded together might become strong enough to do so. So almost as soon as there were factories, the workingmen began to form societies, known as trade unions or labor unions, to improve their condition. From the early days to the present there has been an almost constant struggle between unions of workers and employers.

Gradually the workers in many trades and in many parts of the country have secured shorter hours and better wages.

But even with these improvements many workers have never earned enough to live in the way we think is right. And even in times of our greatest prosperity there were many people able to work and willing to work who had no jobs. In many of our cities today there are parts which we call the slums, where families are crowded together in miserable tenements, with dark rooms where the daylight never enters.

A slum area in New York.

The land we live in is the richest country in the world. We can grow more food than we can eat. We have plenty of power to run machines to make our clothes and other things we need for comfort. Here, if anywhere in the world, it would seem that anyone who is willing to work should be able to make a comfortable living. And yet, in this land of plenty, life for many people is still an endless struggle for bare necessities. Why is this? The explanation seems to be that with machines we have found the way to produce enough for everybody, but we have not yet learned how to get the things produced to all the people who need them.



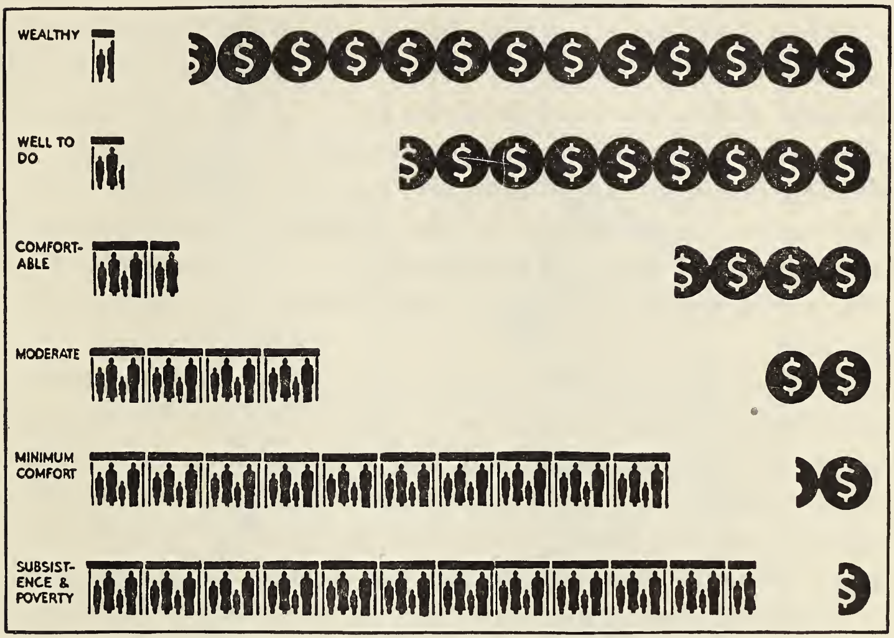
Courtesy New York Housing Authority

An architect's drawing for new low-priced apartments erected on the same site.

Different people have different opinions as to how to solve this problem. Some think that higher wages should be paid workers, so that they can buy more. Wages have steadily increased since the early days of the Industrial Revolution, but not enough. Even during good times there are hundreds of thousands of people who cannot buy the things they need. Another suggestion is that workers should have shorter hours so that jobs may be more widely distributed among them. Many people still have to toil long hours, while others have not enough to live on because there is no work for them. The trouble with these plans is that if the cost of producing things is raised beyond a certain point through raising wages, the employer does not make a profit. Then he must raise the price at which he sells his goods and the working people, even if they have higher wages, are no better off than they were before, for they have to pay more for the things they buy.

Still another suggestion is that the prices of goods should be reduced so that people can purchase more with the money they receive. With more and more efficient methods of producing things, the cost of producing them can be reduced and the manufacturer can sell his goods for less and still make a profit. In this way everyone would benefit, for everyone is a consumer.

The rapid development of business has brought with it another big problem. Over and over again since the Industrial Revolution began, there have been hard times every few years. In the days before machines, when men worked with only simple tools to help them, a man could produce but little more than he could consume. But since the power-driven machine has come into general use, man's power to produce has been multiplied many, many times. Factories turn out such great quantities of goods that after a while there are more of some things than people can buy. Shopkeepers find their stores stocked with more things than they can sell, and they cut down their orders to manufacturers. Then the machines in the factories must be slowed down and many employees are thrown out of work.



Committee on Economic Security

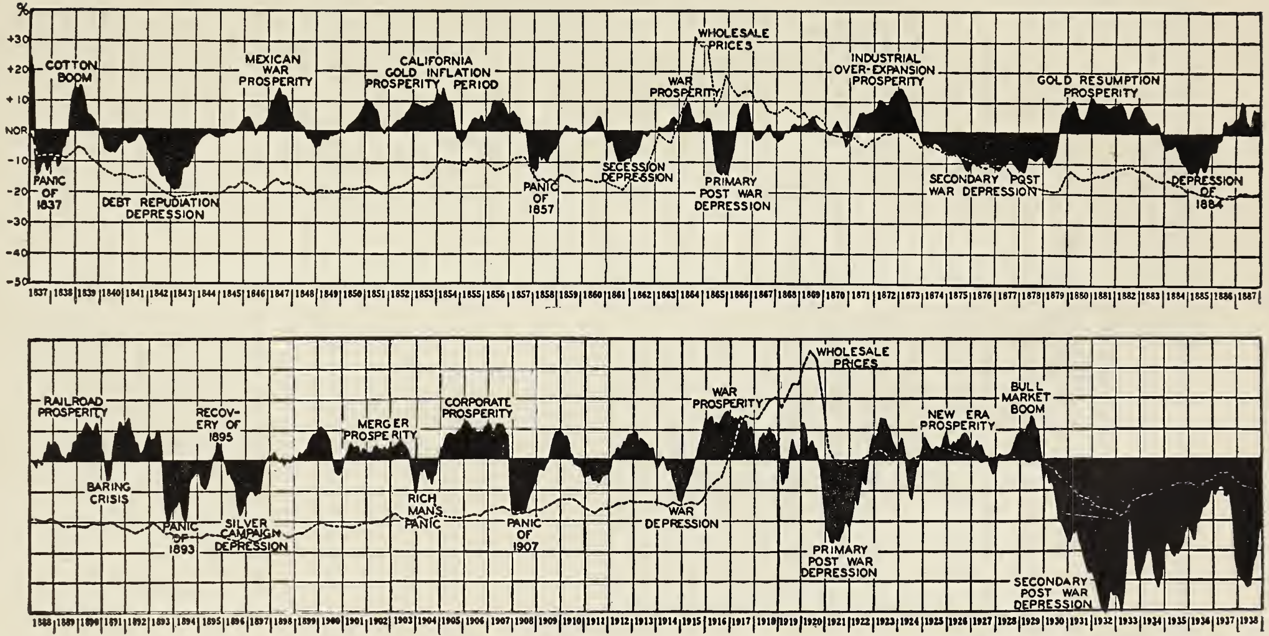
How America's families share America's income. This pictograph shows how the national income was distributed in 1929, the year of our greatest prosperity. Each family group represents a million families; each circle $2,000. Notice the number of families living on less than $2,000.

To try to get rid of the goods they have, storekeepers reduce the selling price. But when many people have no jobs they have little money with which to buy even low-priced goods. As the stores cannot sell they cannot order more from the factories. Many industries close down completely and businessmen fail. This is called a depression.

When factories close they buy no more raw materials; so workers in those fields are affected. When raw materials and finished goods are not sent from place to place by boats or railroads many workers are not needed and are laid off. So the depression spreads to more and more people and gets worse and worse. There is need for the products of the farmer and he wants to sell them, yet he cannot do it. There are thousands who are in need of the output of the factories, yet the machines are idle.

After several years the goods in the stores are sold and the storekeepers begin to order new supplies. Then the factories begin to produce again and employment increases. With wages coming in people can buy more. Then we are once again on the road to recovery and finally to prosperity. But after a time the process begins all over again. Again too much is produced, then people are laid off and we are in another depression. Thus we have the ups and downs of business every few years.

This is a very great problem which the industrial age has brought with it. Why is it, when farmers are ready and anxious to produce things on their farms and businessmen are anxious to keep their mills running year in and year out, when people need food, clothing, and many other things produced by the farmer and businessmen and would buy them if they could—why is it that every little while the wheels of industry stop running?



Courtesy Cleveland Trust Co.

This graph shows the ups and downs of business during the last hundred years.

As long as many people lived on farms the depressions did not affect such a large part of the population. Farmers still had their farms and could usually manage to get along on what they could raise even when business was bad. But as we grew into an industrial nation a greater and greater number of people became dependent upon wages and salaries. When they lose their jobs they are no longer able to get the things they need. It is for this reason that depressions now are so much more severe than they used to be. What can be done about the ups and downs of business which every few years bring distress to so many people of the country?

CHAPTER XXIII

Our Interdependent World

In the days before the Industrial Revolution the people of a community supplied most of their own needs. This made them more or less independent of the rest of the world. But this was not a very satisfactory state of affairs, because by it the people could have only what they themselves were able to produce. With the coming of the new methods of transportation in the nineteenth century people no longer had to depend upon their own neighborhood for the things they needed. Things could be brought to them swiftly from other parts of the world.

Because of the differences of climate, soil, or natural resources, every nation is able to produce some things more cheaply and efficiently than others. Today, because of world-wide trade, the people of one nation can concentrate on the industries for which their country is best suited, send over the world what they don't need, and receive in exchange from other countries things which they cannot grow or make. In this way each nation benefits by what other countries have, and thus the standard of living of the people everywhere is improved. But because of this world-wide exchange of goods, the welfare of the people in each nation has come to depend upon almost every other country in the world.

Some countries depend on others for the very necessities of life. When industries were developing, some nations gave up trying to feed themselves and depended upon the export of their manufactured goods to bring them the money to buy food and other necessities. In becoming a manufacturing nation England, for instance, became dependent upon the outside world for most of her food and for many raw materials necessary for her industries. Four out of five people in England live in towns and cities. If her supply of food and raw materials were cut off for any length of time England's cities would be filled with hungry people.

Because of the great wealth of natural resources in this country it might seem that we could produce within our own borders everything to make us comfortable, but if you think about some of the things we have you will see that many other parts of the world contribute to our well-being.

On our tables every day are foods that we do not raise at all. The sugar in your sugar bowl probably came from a near-by grocery store, but it had to make quite a long journey before it got there. Perhaps it came from Cuba or Puerto Rico, where it is raised on great plantations. After the sugar cane is cut it is taken to sugar mills, where it is put between giant rollers which press out the sweet juice. This is boiled and allowed to cool and the sugar crystallizes. Then it is packed in bags and loaded onto ships to take its long water journey to the sugar refineries of this country where it is made into the white granulated sugar with which we are all familiar.

Do you like bananas? All the year round we can get this delicious fruit from the fruit store, yet no bananas are grown in this country. Trim white ships bring them from our southern neighbors bordering on the Caribbean Sea, where there are some of the greatest banana farms in the world.

Many people enjoy a cup of tea in the afternoon or with their meals. Tea also must take a long journey from the tea-growing countries before it reaches us. Perhaps it grew in Formosa, or on the great plantations of Ceylon, India, or other faraway countries. There on the gentle slopes of hills the tea-pickers work diligently, with baskets strung by cords

Courtesy The United Fruit Company

We are dependent upon workers in tropical lands for our bananas.

Screen Traveler from Gendreau

Javanese women gathering the tender leaves and buds from the tea bushes.

about their necks, to hold the leaves. Afterward the leaves are spread out on large trays to dry and each leaf is rolled up tight. Then the tea is packed in lead-lined chests and is carried to the nearest seaport for its long sea voyage to America.

Another drink that people like is cocoa, made from the cocoa plant, which grows in tropical countries. At picking time groups of negroes go into the cocoa groves and cut off the pods with sharp knives which are fitted to long poles of bamboo. The beans are scooped out of the pods and spread out in the sun to dry. Then they are put in strong jute bags and shipped to this country, where our manufacturers make cocoa and chocolate out of them.

We use a great deal of coffee in this country. There is scarcely a household where it is not served for breakfast and in many homes it is served for other meals as well. But no coffee is raised in the United States. It comes to us from Colombia, Venezuela, Peru, Ecuador, Bolivia, Brazil, and other countries. Freighters bring the green beans to this country. They are taken to the plants of many coffee roasters, where they are roasted into golden-brown coffee.

We like many other foods, such as figs, dates, cocoanuts, almonds, spices, olives—all of which have to be sent us from distant lands. Many of these foods are not absolutely necessary; we could get along without them; but many people are used to having them and would miss them if they were unable to get them.

The same thing is true of our clothes. The United States uses more wool than our sheep can provide us with. We depend upon England, the Argentine, Australia, and other countries for good-quality wool to keep us warm in winter. Silkworms in China or Japan spin silk for our dresses, our stockings, and so on; and flax that grew in Ireland or Belgium is used for fine handkerchiefs, tablecloths, and napkins.

Can you think of other things for which we depend upon other parts of the world? What about rubber? Think what would happen if we were cut off from our supply of rubber. There would be no automobiles, for they would have no tires. Fast trains would have to stop running, for they would have no air brakes to stop them. No airplanes could fly, for it is the rubber tires which make the airplane safe when leaving and returning to the earth. If fire broke out in a com-

Courtesy National Coffee Department of Brazil

Drying coffee in Brazil.

munity the firemen would have no hose for putting it out. Telephones would be silent, electric lights would not work; there would be no radios, no balls to bounce, no elastic bands, no erasers, no overshoes, no raincoats. We are, indeed, dependent upon rubber; yet not an ounce of rubber is grown in this country. Every bit of it has to be brought to us from tropical countries.

These are only a few illustrations to show how the far corners of the world minister to our everyday needs. We might go on naming many other things from other parts of the world which we are using and enjoying daily.

What about the things we grow or make in this country? Every day people in other parts of the world use many things that come from our country. In our Southern states we grow great quantities of cotton. Our factories are able to use only a part of what we can raise; the rest must be disposed of elsewhere. When foreign purchases of cotton fall off, every Southern state is affected. Our great wheat fields in the West produce enough wheat not only for the people of this country but also for people in other parts of the world. Our factories turn out goods so fast that we have much more than the people of this country can use, and our manufacturers of automobiles, reapers, typewriters, sewing machines, and many other things are dependent upon people all over the world who want to buy them.

So you see that although the United States is particularly favored with natural resources our country is unable to produce everything we need and we cannot very well get along without things produced in other parts of the world. We have become accustomed to a high standard of living and to enjoying a wide variety of food, materials for clothes, and things for everyday use; and we call upon the whole world to supply these. On the other hand, the very fact that we produce so much makes it necessary for us to sell our products to other countries. America depends on the world, and the world depends on America.

All industrial nations need immense quantities of raw materials. If a nation does not have enough coal, iron, oil, rubber, cotton, and such things, it must get them by trade with another nation or it must obtain territory in which they are to be found. Businessmen want to control, if they can, the sources of the raw materials upon which their business depends. For this reason, the nations of Europe have expanded into empires, with foreign possessions which are rich in raw materials. These possessions also provide markets for the goods manufactured by their businessmen.

But not even the large colonial empires of nations are able to supply the ever-increasing need for raw materials. Therefore businessmen with surplus wealth often invest their capital in foreign countries that have important natural resources which the people of the country are too poor to develop themselves. They have developed sugar plantations, rubber plantations, pineapple plantations, and so on, in various parts of the world; they have bought land in other countries containing oil, iron, coal, and other important industrial materials. Such enterprises often lead to ill feeling between the nations concerned.

The success of every industry depends upon the sale of its products. When the businessmen of a country cannot sell all they are able to produce to the people of their own country, they look about for markets in other parts of the world. Enterprising businessmen of the industrial nations have sought markets in every corner of the world, always looking for new opportunities to sell their goods. Competition between the businessmen of various nations sometimes leads to friction between these nations, which, in turn, sometimes leads to war.

One of the greatest questions for the world to consider today is whether each nation shall pursue its own way, gaining trade and territory at any cost, or whether there shall be world planning and world cooperation that will give each nation its rightful share of world trade. The new industrial age has bound all nations into one interdependent community; so unless world trade is regulated in some way it is hard to see how there can be anything but war after war to obtain raw materials and markets. Each part of the world today depends on every other part and all parts must cooperate if the welfare of the whole is to result. This is the most important lesson which the Industrial Revolution has to teach us.

Some people think that America, with its rich and varied resources and protected by two wide oceans, should pursue its own way and leave the rest of the world to get along as best it can. But we have seen that America is linked by ties of trade with all other parts of the world and that its well-being and prosperity are dependent upon other countries. So America must play its part in the interdependent world which the Industrial Revolution has created. We must work with other nations for world-wide, international cooperation, so that the vast riches of the earth may be made accessible to the people of all nations. It is only when the nations of this interdependent world of ours learn how to live and work together that the people of the world can hope for peace and happiness.

CONCLUSION

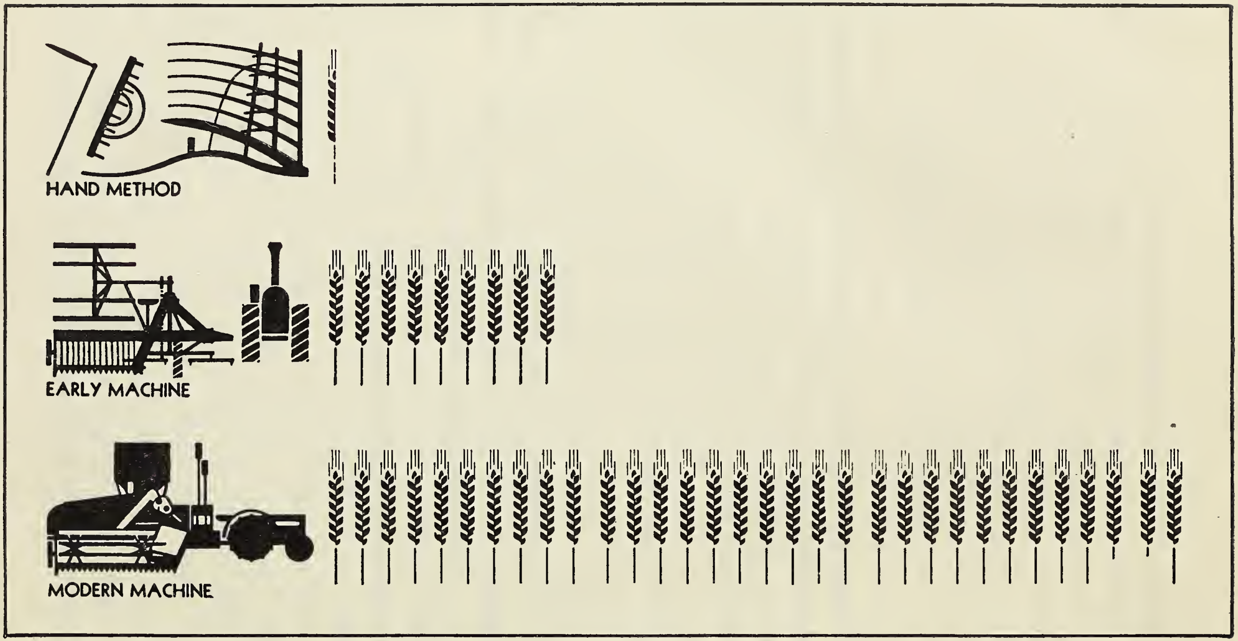
A New Age in the Making

WE HAVE traced many developments of the last hundred and fifty years which have produced the industrial world in which we are living today. We have seen man's long struggle to find substitutes for the strength of his muscles and those of animals, and for the uncertain help of wind and water, which were all he had to help him do his work in the long ages before the invention of power-driven machines.

For untold ages the energies of men were consumed in the task of making a living, of producing enough to supply them with the necessities of life. Then, in the eighteenth century, they discovered the boundless natural resources of the earth and learned how to use them for their own advancement. They made many wonderful inventions; they learned how to construct giant machines, and how to harness the forces of nature to do the work of the world. They developed new methods of organization and financing of business, by which the newly discovered materials and forces of nature could be made to produce things on a huge scale. They invented new forms of transportation and communication and built up a world-wide trade, so that today people can draw on the vast riches of the whole earth for their everyday needs and comforts.

It is the most amazing transformation the world has ever known. A little more than a hundred years ago the first steamboat puffed its way up the Hudson; today giant liners make their way to every part of the world. In 1825 the first railroad in the world ran at the unheard-of speed of twelve miles an hour; today railroads make a network over all the land areas of the earth. In 1859 the first oil well was drilled; today, less than a hundred years later, oil is used all over the world. In 1846 little forges turned out a few pounds of iron; today there are enormous quantities of steel for all sorts of great constructions. In 1831 McCormick was building his little reaper in a shed; today there are all kinds of machines to help the farmer in his work. In 1844 Morse was making his first telegraph with bits of wire and wood; today the whole world is connected by telegraph. So we might go on with a long list of the achievements of the brief century and a half which have passed since Hargreaves, Arkwright, and the other poor spinners and weavers in England began making their simple improvements on their spinning wheels and looms.

In the building up of civilization through the ages the people of each generation contribute their share. All, working together at their daily tasks, create something which endures after them and becomes the foundation upon which the next generation builds. It is in this way that world progress takes place. As the result of people's work during the last two centuries, we are now at the beginning of a new age in the world's history, for by means of the power-driven machine man may be released from the backbreaking, time-consuming toil for a livelihood that characterized his life before the In-



National Resources Committee

How machines have increased production in the last hundred and fifty years.

dustrial Revolution, and thus may be free to develop the finest kind of civilization of which he is capable.

Ever since its earliest days America has been looked upon as the land of opportunity. To our shores have come people from every nation of Europe. One and all, they have flocked here with the hope of working out a better, happier life for themselves and their children. We have seen that in the distribution of the natural resources which are the basis of our present civilization our country has been unusually fortunate. Today, as never before, we have the chance to make America really a land of opportunity—a land where every family, as a result of its work, shall have what its members need to eat and to wear; where every family shall be decently housed; where people shall be released from long hours of monotonous toil that deaden the mind, and may be able to live a higher type of life than has ever been known in the world.

Also today, as the result of the Industrial Revolution, all the people of the world have been united through the interdependence of nations. This gives the opportunity, for the first time in history, to build up a world community, in which the people of every nation may peacefully pursue the paths of industry and cooperate with the people of other nations, so that everyone may benefit by the age of plenty produced by the Industrial Revolution. This is the next great step in civilization.

In this new age which is just now coming into existence, you of the rising generation will play an important part. This new way of living created by the machine has brought with it many problems, seriously affecting the happiness of people, which our generation is working on, and which you may help to solve when you grow up. Through the work of the generations which preceded us the material foundation for a great age has been laid, but unless these material riches make it possible for people to live better, happier lives they have not contributed anything to civilization. Join hands, then, in helping to build up a new world community, one which will bring a fuller, happier life for everyone, not only of this nation, but of every nation—a life more free and peaceful than any the world has ever known.

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